22 THE PRINCIPLES OF THE APPLICATION OF GRAVIMETRY

The interpretation of gravimetric data is based – as a rule – on the Bouguer anomaly map. The Bouguer anomaly is computed by the formula:

$$\Delta g = \Delta g_0 - (\Delta g_\varphi + \Delta g_F + \Delta g_B + T)$$

where

Δg_0 = observed gravity value,
Δg_φ = normal correction (according to the international formula),
Δg_F = elevation correction,
Δg_B = Bouguer correction,
T = correction for the surrounding terrain (topographic correction).

The corrections within the brackets are intended to allow a comparison of values observed at different latitudes and elevations. For this reason, the values depending on geographical latitude are subtracted from the observed values and the rest is reduced to a certain level (usually sea-level).

The computation of normal correction and elevation correction involves no difficulty, since they are merely geodetic data. The determination of the average density (σ), however, required by the Bouguer and the topographic correction, is – especially in mountaineous area – a fundamental problem of the gravity interpretation.

First of all, it must be realized, that reduction to sea-level rarely, if at all, represents the gravity effect of masses below sea level only. The Bouguer effect: $\Delta g_B = 2\pi f \sigma h$, represents the effect of an infinite, homogeneous plane slab of *h* thickness, situated above sea-level. It is really "good luck" if the latter is identical with the effect of an actual slab (rock formation) which is rather variable as a rule. Practically, however, this can never be expected, especially not in mountaineous regions. Since topography can be regarded as a modulation of the Bouguer slab, it can easily be understood, that the topographic correction requires just the same density-value as the Bouguer correction does. Hence, in the following, the question of topographic correction will be neglected.

The Bouguer correction is destined to eliminate those "apparent" anomalies only, which are not caused by density change and which cannot be removed by Faye correction (i.e. by the simple elevation correction of the observed values).

It can be seen on Fig. 3, that the first maximum of the Faye anomaly (*a*) and the neighbouring minimum (*b*) mean no lateral density change, these appear merely as effects of topography. The second maximum (*c*), however, partly indicates an actual density surplus. On this generalized diagram, no accidental buried density-changes are represented, since such – if any at all – cannot be taken into consideration (correction), no matter whether they are situated above or below sea level. Such acting masses ***will***, in any case, *cause* an anomaly in the anomaly-pattern after the reductions. Whether they are below sea level or above it, this can be decided (perhaps) through further computations. This shows again, that reduction to sea-level must not be understood word for word.

The role of the Bouguer anomaly is – after having subtracted the effect of the homogenous mass visible on the lower part of Fig. 3 – to characterize the actual density changes. No doubt, not all "apparent" animalies can be eliminated with the aid of the Bouguer correction. For example, the limestone peak (*d*) on the right side of the figure involves no density anomaly as compared to the immediate surroundings, neither does anomaly *a*. The *a* is a hillock built up of the sedimentary material of the basin, *d* is a summit built up of the material of the basin-floor (exposure). If not knowing or not considering this geological fact ($\sigma_2 \gg \sigma_1$) the effect of a homogeneous block (on the lower part of Fig. 3) is subtracted from the Faye anomaly, only a part of the apparent anomaly *d* disappears. No wonder, since a density value, smaller than that existing in reality (that of the material of the peak) was used.

Consequently, the problem of the variable density correction steps into the foreground. In this very case, it means that, instead of the effect of the homogeneous block mentioned (see Fig. 3), we have to subtract the effect of such a variable density block (possibily representing the actual density-conditions) as would entirely remove the effect of the greater density elements of the topography too.

This question leads to two unsolvable problems. These problems are: to determine the correct density values, and to delineate the strips of different densities.

Well, laboratory density-determination (on rocksamples) is rather uncertain. The dispersion of the observed values is too great. Ordinarily no samples in proper quantity and properly collected are at hand.

Density can be determined from gravimetrical data too, although so only an average value valid for a larger area can be obtained. Consequently, "apparent" anomalies again cannot be eliminated. On the contrary a new difficulty arises: how to appoint the borders between areas of different densities? This is a question not to be underestimated, since an incorrect boundary delineation leads to false anomalies.

The topographical monotony and the loose, young sediment (alluvium) character of the region are interrupted by two massive blocks emerging from the basin-floor to the surface like two islands: the Mecsek mountains and the Villány mountains. In order to avoid the problem of the correct density (i. e. density strips), in preparing the anomaly map (Fig. 9) the actual densities of both mountains were not considered (they had not been known either); even in the mountainous area, density value $\varrho = 2{,}00$ g/cm^3 of the surrounding Neogene was applied in the Bouguer correction. This value is valid in general, on the greatest part of the Hungarian basin. Thus, our map can be connected to the adjacent ones without difficulty.

It follows of the procedure mentioned, that both mountains cause positive anomalies larger than that justified by their actual density contrasts. The anomaly is increased by the deliberately applied smaller correction.

In this way, the Bouguer anomaly is in correlation with topography. This, however, is not disadvantageous on such areas, where topography and geological structure are in connection (island-mountains). The deliberately made error enhances just what is expected in an area of outcropping mountain: the shape and boundaries of the exposure as a whole.

In the open basins, the situation is quite different. Since on places like this, no considerable near-surface density-anomaly can be assumed (neither is the topography rugged), the Bouguer anomaly must evidently be apt to indicate the effect of deep bodies. In an area of basin character, the basin-floor may be supposed in first approximation as a deep body, since the greatest density contrast can be attached only to its surface. The same applies to our region.

While the density of the Neogene basin sediments ranges between 1,9–2,2 g/cm^3 (in the function of depth too), the stratigraphical and petrographical range of the basin-floor covering from Proterozoic to young Mesozoic, ranges in density between 2,5–3,0 g/cm^3.

The density of the individual rocks building up the basin-floor may vary just the same way (though not after the same rule) as seismic velocity and specific resistivity. On the other hand, several rocks have overlapping (identical) densities. Consequently, the individual rocks of the basin-floor – merely gravimetrically – cannot be distinguished.

The aforementioned rule, that anomalies are – in first approximation – apt to indicate the effect of the basin-floor, is not of general validity. For example, deep (Ellend) and shallow (Turony) basin-floor parts, too, are known having identical anomaly-values. Confronted by such phenomenon, one has evidently to conclude to a smaller density of the basin-floor in the latter case, than in the former one. Ellend lies over the South-Baranya crystalline ridge, so the basin-floor is crystalline (2,7–3,0 g/cm^3). At Turony, the basin-floor is composed of thin Lower Triassic (clastic) sediments underlain by Permian sandstone (the density of which is, at the given depth: 2,5–2,6 g/cm^3). The importance of complex investigation and complex interpretation can claim no better proof.

A detailed study of the Bouguer anomaly map will be given later. Now, still a short discussion of the problem of the secondary anomalies is needed. An experimental computation of the $\partial^2 g/\partial z^2$ secondary anomalies was made for the region with the *Elkins* method. In the Mecsek and Villány mountains themselves (on the exposures) no more information could have been expected (owing to the "apparent" anomalies mentioned) than that of the Bouguer map. The strongest acting mass is (or may be) just on the surface, being an exposure, consequently no prevalence of deeper masses can be expected. This is a general comment referring to any secondary anomaly computation in outcrop-areas.

Neither offers *Elkins*-map, even in basin areas, a detailed interpretation, which is assumed to be due to the rugged topography and varied consistence of the basin-floor in the region. This means that the different bodies cannot be separated by secondary anomaly computations either. In fact, the question of higher derivatives is not entirely clear even in open basins. The investigations are in progress. The *Elkins*-map is, at present, not suitable for publishing. Depending on the results of the investigations, eventually it will not be published at all.

Also the experimental computations aiming at depth determination proved an unsuccess. The reason of this is supposed to lie in the fact, that only the elevated blocks of the basin-floor can be taken for local acting masses.

Delimitation of the latter from the regional acting mass – which is similarly basin-floor – is arbitrary and not unambigous at all.

In spite of this, the gravity map can be used in some places to estimate the depth of the basin-floor. This, however, requires either a number of deep-drillings in the neighbourhood or at least one of the quantitative type (seismic, geoelectric) geophysical methods. The relation between the depth-data of basin-floor and anomaly values, as recognized locally, can be extended to a greater distance from the respective seismic or geoelectric profiles. Such depth-data are, however, not free from the uncertainties of extrapolation.

23 THE PRINCIPLES OF THE APPLICATION OF THE MAGNETIC METHOD

While, within the sphere of gravity phenomena, only attracting forces are to be considered, magnetic phenomena involve attracting forces as well as repelling ones. Accordingly, magnetic boides show bipolarity; only the combined effect of both poles can be examined. While a gravity maximum permits a rough conclusion to something being "up", and a minimum indicates roughly something "down", the magnetic maxima and minima may have independent and perhaps identical geological meaning. Taking a vertical magnetic magnetic body, the meaning of the maximum is not "up" but a near-surface negative (southern) pole, the meaning of maximum is not "down" but a positive (northern) pole near the surface. In the case of horizontal and oblique bodies – because of the bipolarity – a maximum is necessarily accompanied by a minimum. The location of the latter (as compared to the maximum) depends on the spatial orientation and depth of the body. For the depth, the character of the change is characteristic, not the character of the anomaly (whether maximum or minimum).

The basic principle of the geomagnetic method is, that the magnetic field of the Earth can be described – in first approximation – as the vector-field of a magnetic dipole, and the materials of the Earth's crust are differently magnetized in the field of this dipole. Thus, they distort the theoretically even distribution of the terrestrial magnetic field, i. e. they produce anomalies.

Rocks are not equally magnetizable. The material constant, showing the possible magnetization of a certain material, is called specific magnetizability, or *magnetic susceptibility*.

The value of the magnetic intensity as observed at a certain location, depends on the susceptibility of the rocks of the site, and on the depth of the body.

The magnetic *anomaly* is the difference (ΔZ, ΔH) between the intensity observed at the given location, and the normal value described by a quadratic function.

The magnetization causing an anomaly can be reduced to two components. One of them is the *induced magnetization*. This kind of magnetization, as to its degree and direction, is a function of the presently dominating magnetic field and of the susceptibility of the rock. The other component is the *remanent magnetization*.