SOME PARTICULARITIES OF THE GRAVITY SURVEYS PERFORMED WITHIN THE CONTINENT–SEA TRANZITION ZONES. AN APPLICATION IN THE SOUTHERN DANUBE DELTA

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Abstract: The increasing detail of geosurveys carried out both onshore and offshore points out the great importance of the continent-sea transition zones for a global understanding of the shallow and also deep geological structure of continental shelves. Due to the specific features of these areas, usually classic geophysical surveying methodologies can not be applied. Potential fields based geophysical methods prove their enhanced ability of bringing valuable structural and lithological data by completely environmental friendly means at a significant lower cost and with no anthropic impact in comparison with seismic methods. A trustworthy evaluation of the unhomogeneity that globally characterizes any randomly distributed data set is possible by determination of its fractal dimension. The outputs of the analysis represent proper means for a better observation network design and, also, for an optimized stocking of data into grid networks. A full comprehension of the Bouguer anomaly significance and of its step by step computation procedure has been proven to be very important for a gravity anomaly map's interpretator. Several particular relations between gravity station positions on one hand and the fresh or salt water level and the geodetic ellipsoid's surface on the other hand, may appear during data acquisition campaigns, due to specific features of continent-sea transition zones. The great importance of an accurate Bouguer anomaly computation for each of the particular cases that may appear within a transition zone extends also on the recommendation for standardized gravity anomaly computing procedures and data banks.

Key words: gravity mapping, continent-sea transition zone, fractal dimension, Bouguer anomaly.

INTRODUCTION

The extraordinary development of the seismic methods recorded during the past few decades, unfortunately pushed the potential fields based geophysical methods into an undeserved shadowy position. Despite of this worldwide remarked situation, the gravity and magnetics are still able to provide new, genuine, low-cost geological information that seismics are sometimes, for different reasons, unable to get.

The significant improvements of both gravity meters and magnetometers, their ability of being also aircrafted, at a very low cost comparing to seismic surveys, both onshore and offshore, should focus again the interpretators attention on these classic geophysical methods. The capability of potential fields based investigation methods to bring, by completely environmental friendly methodologies, both structural and lithological data, correlable to sedimentary basins, crystalline basements and others, has been fully proved during time. This feature is quite important for the surveys carried out in high sensitive areas such as coastal zones, estuaries, deltas and lagoons.

CONTINENT-SEA TRANSITION ZONE MAIN FEATURES

A continent-sea transition zone (CSTZ) comprises usually the marine shallow water zone and the coastal areas beside it. In the case of Romania, the transition zone (Fig. 1) contains also the Danube River–Danube Delta ecosystem, including the Razelm-Sinoie lacustrine complex.

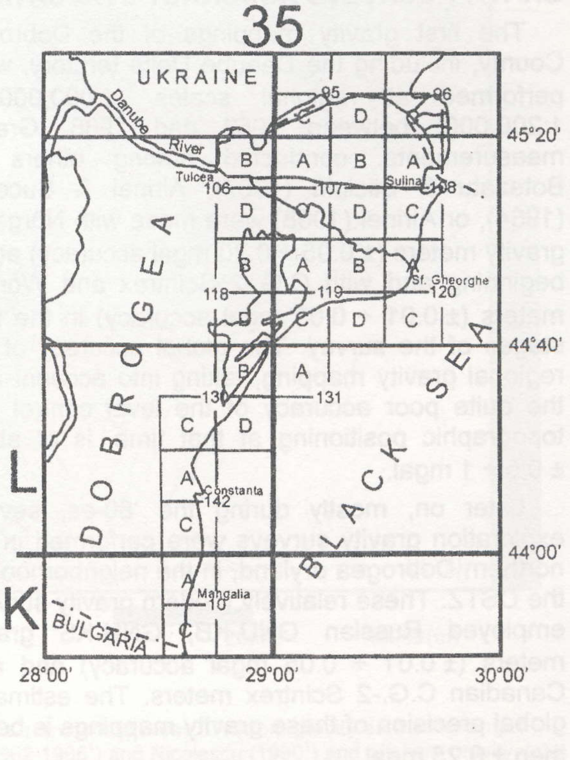

Fig. 1 Romanian continent-sea transition zone, pointed out by the 1:50,000 scale map sheets

The transient feature of this area refers first of all not to the underlying geological structure, but to the demanded surveying methodologies. Usually the main features of the transition zones, that are very important for exploration activities, are:

- stressed, even endangered, ecosystems that are high sensitive to the most of the anthropic activities are present. For instance, almost the entire area of the Romanian CSTZ belongs to the Danube Delta Biosphere Reserve;
- active geodynamic processes, such as actual vertical movements, shore line erosion, sediments transport and sedimentation and others are present within the area;
- recent unconsolidated sediments and shallow waters quasi-totally cover the older geological formations;
- high irregular geological and geophysical observation data networks cover the CSTZ due to the lack of access ways within large areas such as swamps and deltas.

The specific, non-pollutant, environmental friendly geophysical methodologies developed for Romanian CSTZ surveying during time, paid a great deal of respect to the not disturbing of the genuine local habitats and ecosystems.

GRAVITY SURVEYS ACCURACY EVALUATION

The first gravity mappings of the Dobrogea County, including the Danube Delta territory, were performed at regional scales (1,000,000 ÷ 1:200,000) between 1952 and 1966. Gravity measurements, conducted among others by Botezatu & Băcioiu (1957), Airinei & Suceavă (1964), or Airinei (1968) were made with Nörgaard gravity meters (± 0.05 ÷ 0.20 mgal accuracy) at the beginning and with C.G.-2 Scintrex and Worden meters (± 0.01 ÷ 0.03 mgal accuracy) in the final stages of the survey. The global accuracy of the regional gravity mapping, taking into account also the quite poor accuracy of the level control and topographic positioning at that time, is of about ± 0.5 ÷ 1 mgal.

Later on, mostly during the '80-es, several exploration gravity surveys were performed in the northern Dobrogea dryland, in the neighborhood of the CSTZ. These relatively modern gravity surveys employed Russian GNU-KB, GNU-KS gravity meters (± 0.01 ÷ 0.05 mgal accuracy) and also Canadian C.G.-2 Scintrex meters. The estimated global precision of these gravity mappings is better then ± 0.25 mgal.

Marine gravity mapping of the Romanian continental shelf started in 1980. It employed at first Russian on-bottom GD-K gravity meters (± 0.15 mgal accuracy), after 1984 Russian on-board GMN-K meters (± 1.5 ÷ 5 mgal accuracy) and since 1990 GMN-KM on-board meters (± 0.7 mgal accuracy). The marine geophysical surveys positioning was made by hyperbolic radionavigation systems (HiFix-6 and Brass-3) before 1990 and by GPS receivers after it. The reported standard error of the marine gravity mapping carried out by on-board GMN-K units, computed in the crossover points of the network, is ± 1.4 mgal (Sava, 1985). Unfortunately, due to the specific requirements of the marine geophysical surveys, only very small sectors of the marine shallow water zone have been covered by measurements.

Experimental at the beginning, systematically later, gravity surveying of the Romanian CSTZ started in 1988. The research project employed on-bottom and also terrestrial gravity meters, in order to determine the variations of the gravity acceleration on the bottom, on the surface of the shallow water zones and along the spits, banks and dykes of the Danube Delta. The gravity station positions were obtained by classic topographic means at the beginning of the survey and by GPS receiver's fixes during the last past years. The reported gravity determination accuracy is of ± 0.12 mgal for the on-bottom measurements (Dimitriu et al., 1992) and better for the on surface

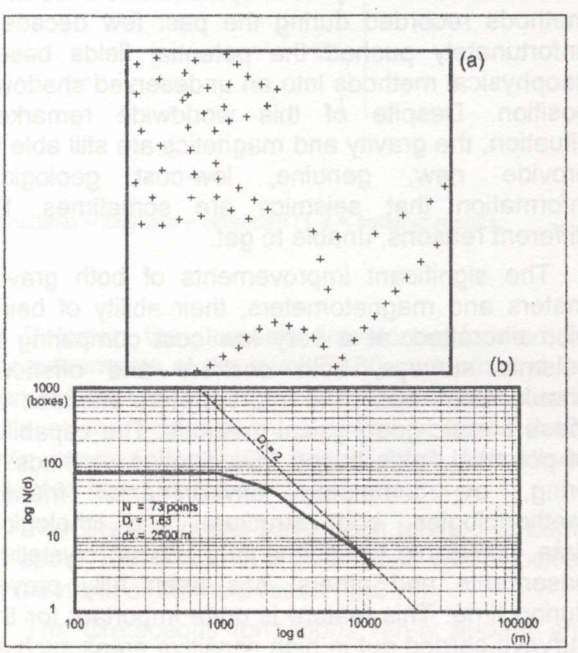

Fig. 2 Fractal dimension analysis of the old gravity data set randomly distributed within the Doloşman-Bisericuţa area (20x20 km); (a) Old, exclusively terrestrial gravity station locations; (b) Results from the box counting method for stations network of (a)

and terrestrial ones.

The level of the gravity stations has been determined with an accuracy better then ± 0.10 ÷ 0.20 m, usually by a very careful monitoring of the fresh water level during the data acquisition campaigns. Summing the estimated errors due to gravity determination, to inadequate computation of the gravity station level, or of its true latitude, a global accuracy better then ± 0.25 mgal for the transition zone gravity mapping is obtained.

DETERMINATION OF THE GRAVITY DATA SET FRACTAL DIMENSION

The fractal dimension of any randomly distributed data set describes the discontinuity of the spatial distribution and globally characterizes

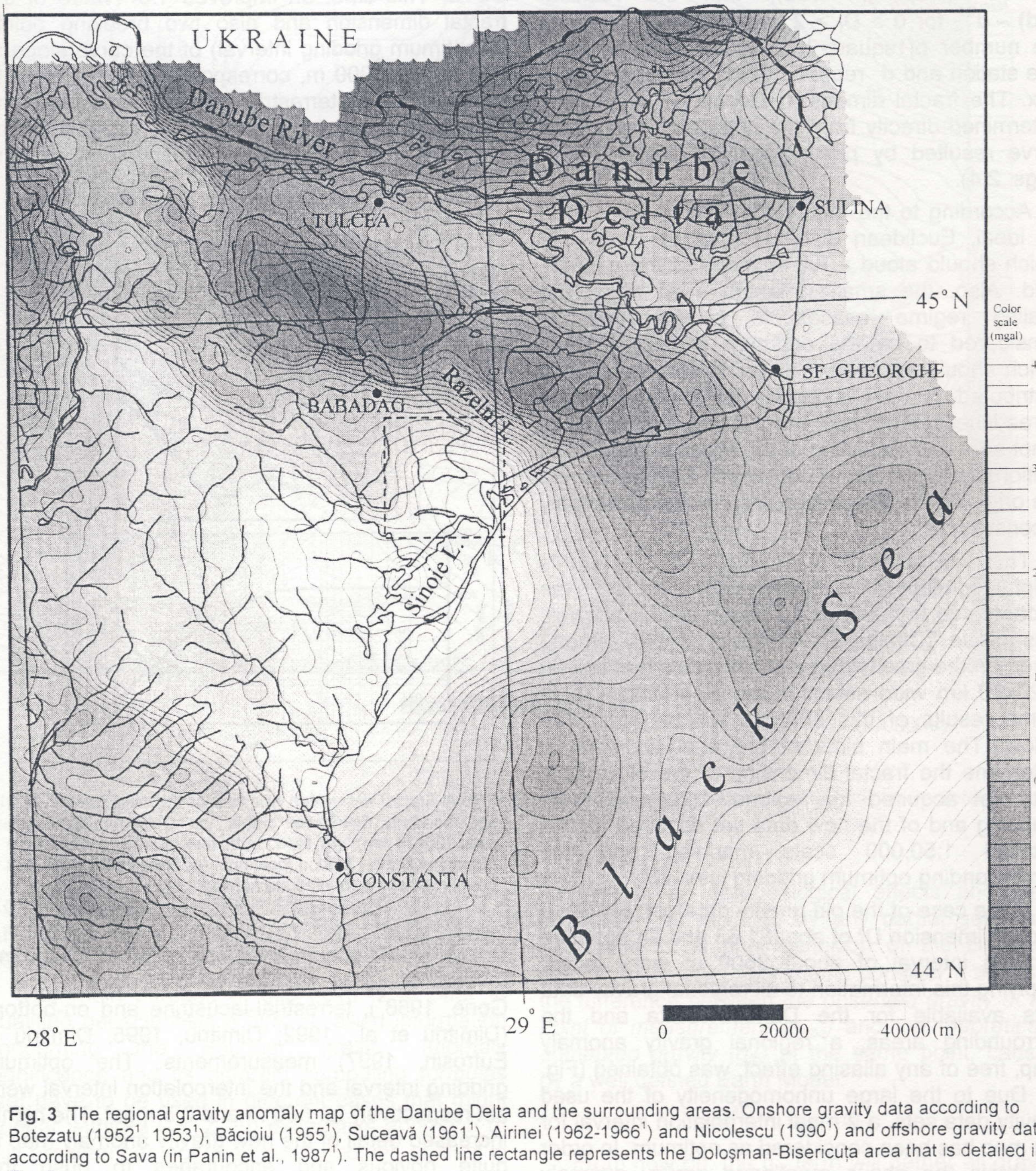

Fig. 3 The regional gravity anomaly map of the Danube Delta and the surrounding areas. Onshore gravity data according to Botezatu (1952[1], 1953[1]), Băcioiu (1955[1]), Suceavă (1961[1]), Airinei (1962-1966[1]) and Nicolescu (1990[1]) and offshore gravity data according to Sava (in Panin et al., 1987[1]). The dashed line rectangle represents the Doloşman-Bisericuţa area that is detailed in Fig. 5

[1] Unpublished surveying report.

the homogeneity of the data set. Making such a statistical analysis of a data set, prior to any land investigation, is totally inexpensive and very useful. Taking into account the available data network and the designed tasks of the project, an average measurement amount and a gross cost of the survey can be predicted.

The fractal dimension $\mathbf{D_f}$ of a data set can be computed, using for instance the "box counting method" (Keating, 1993), with the relation: $\mathbf{N(d)} \sim \mathbf{d}^{D_f}$, for $\mathbf{0 > D_f > 2}$, where $\mathbf{N(d)}$ represents the number of square boxes containing at least one station and **d** represents the size of a square box. The fractal dimension D_f will be graphically determined directly from the negative slope of the curve resulted by plotting logN(d) versus log(d) (Figs. 2,4).

According to the theory, $D_f = 2$ corresponds to an ideal, Euclidean distribution of the data set, which should aloud a full recovery of the genuine field. Also, the smallest length d at which the scaling regime ceases to be constant, is considered to be the optimum gridding interval which should be used in order to stock randomly distributed data into a regular data network (e.g. a spreadsheet). This way, the aliasing effects due to a not adequate sampling of the irregular distributed stations network, can be efficiently filtered out and the original field distribution will also be acceptably reconstituted.

The first attempt in Romania to apply this helpful concept to a geophysical data set was encountered in 1995. A fractal dimension analysis was made (Dimitriu & Eufrosin, 1995), among other, on the gravity data sets available that time in a 20x20 km wide sector of the Romanian CSTZ. Some results of this analysis will be presented below. The main aims of the analysis were to determine the fractal dimension of the old gravity data set acquired for regional 1:200,000 scale mapping and of the new data set acquired for the detailed 1:50,000 scale mapping and the corresponding optimum gridding intervals.

In the case of the old gravity data set (Fig. 2), a fractal dimension Df of about 1.63 and an optimum gridding interval of about 2500 m were found. Applying this information to all regional gravity data sets available for the Danube Delta and the surrounding areas, a regional gravity anomaly map, free of any aliasing effect, was obtained (Fig. 3). Due to the large unhomogeneity of the used gravity data sets, a 2 mgal interpolation interval for the map has been considered as optimum. In order to obtain the above mentioned gravity anomaly map there have been used the original gravity data measured onshore by Botezatu (1952[1], 1953[1]), Băcioiu (1955[1]), Suceavă (1961[1]), Airinei (1962-1966[1]) and Nicolescu (1992[1]) and offshore by Sava (in Panin et al., 1987[1]). In this case, the geological interpretation of the gravity anomaly map should better not extend to anomalies whose wavelengths are shorter then 5 km and amplitudes below 2 mgal.

A second fractal dimension analysis was made on the new gravity data sets acquired meantime within the same 20x20 km wide sector of the CSTZ. This time, an improved 1.87 value of the fractal dimension and also two breaking points (= optimum gridding interval) of the curve slope at 250 m and 1000 m, corresponding respectively to the high density terrestrial station and to lacustrine on-bottom ones, were found (Fig. 4). The gravity anomaly map (Fig. 5) corresponding to the

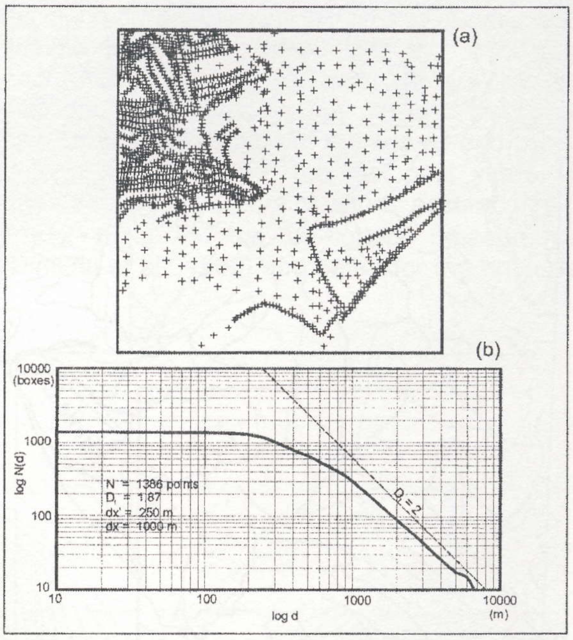

Fig. 4 Fractal dimension analysis of the new gravity data set randomly distributed within the Doloşman-Bisericuţa area (20x20 km); (a) New, both terrestrial and on-bottom lacustrine gravity station locations; (b) Results from the box counting method for stations network of (a)

Doloşman–Bisericuţa area was obtained according to data acquired onshore by terrestrial (Gorie & Gorie, 1986[1]), terrestrial-lacustrine and on-bottom (Dimitriu et al., 1992; Dimitriu, 1995; Dimitriu & Eufrosin, 1997) measurements. The optimum gridding interval and the interpolation interval were set respectively for 500 m and 0.5 mgal. The highly increased detail of the new gravity anomaly map is quite obvious and encourages to push the geological interpretation's limits down to gravity anomalous effects characterized by amplitudes below 1 mgal and average wavelengths of about 1 km.

Fig. 5 The detailed gravity anomaly map of the Doloşman-Bisericuţa area. Terrestrial gravity data on the mainland according to Gorie & Gorie (1986[1])

COMPUTATION OF THE BOUGUER GRAVITY ANOMALY IN A CONTINENT-SEA TRANSITION ZONE

The main purpose of this point is to offer to qualified geoscientists a bulk of rallied information concerning the Bouguer gravity anomaly significance and its different computing formulas that have to be used in different cases that might appear within a CSTZ. An exhaustive approach of this problem has not been published yet, at least in Romanian technical publications.

According to LaFehr (1991a), the Bouguer gravity anomaly should describe a field intended to be free of all non-geological effects and, very important, not modified by any partial geological interpretation. A brief definition of the **Bouguer gravity anomaly** (Δg^B) should consider it as being the difference between the *observed gravity at the point of measurement* (g_{obs}) and the *theoretically computed gravity* (g_{th}) at the same point, caused by a well defined Earth Model.

$$(\Delta g^B) = g_{obs} - g_{th} \tag{1}$$

From now on, the g_{th} term will gather all gravity effects due to defined Earth model, as follows:

$$g_{th} = [\gamma_0 - \partial\gamma/\partial z\, z + 2\pi G\delta z - R_t(\delta) \pm R_s(\Delta\delta)], \tag{2}$$

where:

γ_0 = the latitude dependent theoretical value of gravity (normal gravity) at mean sea level;
$\partial\gamma/\partial z\ z$ = elevation dependent free-air correction;
$2\pi G\delta z$ = gravity effect due to a Bouguer slab of z height and δ density;
$R_t(\delta)$ = gravity effect due to emerged δ density topography;
$R_s(\Delta\delta)$ = gravity effect due to submerged $\Delta\delta$ density bathymetry.

Because both $R_t(\delta)$ and $R_s(\Delta\delta)$ terms evaluate the emerged and submerged topography's effect and extract it from observed gravity values, they are equivalent to and have to be considered as terrain corrections.

All Bouguer anomaly values have to be considered as anchored in the point of measurement and should never be translated to a common datum. It is also strongly indicated to use standardized values for some terms of Bouguer anomaly computation formulas (e.g. the mean density of the Earth's crust, the normal vertical gradient of gravity at the mean sea level, and others).

In order to compute the Bouguer anomaly value in a point P, there will be used as many as necessary Bouguer slabs, whose densities depends on the slab position relative to the geodetic ellipsoid. The empty sectors below the ellipsoid's surface are to be filled with virtual material of crustal density and the parts above this surface should have the average density of the topography.

In all different cases that will be presented in the paper, the reference datum will be the geodetic reference ellipsoid's surface. During the presentation, the following symbols and constant values will be also used:

z = elevation, above the ellipsoid's surface, of the gravity station, positive upward (see Fig. 7);
h = depth, below the ellipsoid's surface, of the gravity station, positive downward;
a = water depth, positive downward;
δ_c = mean density of the Earth's crust (=2.67 g/cm^3);
δ_t = mean density of the surrounding topography;
δ_w^s = mean density of sea water (=1.03 g/cm^3);
δ_w^f = mean density of fresh water (=1.00 g/cm^3);
$\Delta\delta^s$ = $\delta_c - \delta_w^s$;
$\Delta\delta^f$ = $\delta_c - \delta_w^f$;
$2\pi G$ = 0.04193;
$\partial\gamma/\partial z$ = normal vertical gradient of gravity at mean sea level (=0.3086 mgal/m).

Gravity surveying of a CSTZ has to face a large variety of particular situations generated by onsite mutual relations between some key parameters (e.g. mean sea level, fresh water level, terrestrial, on surface or on-bottom gravity station level) that characterize the position of the gravity station relative to the reference datum.

The marine shallow water zones are usually investigated by on-bottom gravity measurements, on surface or on-board measurements being necessary only in rare occasions (Fig. 6). In all these cases the survey follows closely the classic marine gravity methodologies.

According to all previously mentioned notation and consideration, the computation of the Bouguer anomaly for the **on-board gravity measurements** (Fig. 6) has to be made by the following formula:

$$\Delta g = g_{obs} - [\gamma_0 - 2\pi G\Delta\delta^s a \pm R_s(\Delta\delta^s) - R_t(\delta_t)] \quad (3)$$

After the proper substitutions, the computing formula becomes:

$$\Delta g = g_{obs} - \gamma_0 + 0.06877a \pm R_s(\Delta\delta^s) + R_t(\delta_t) \quad (4)$$

The positive and negative terrain correction $R_s(\Delta\delta^s)$ correspond to the gravity effects of bathymetry variations. These effects are caused by the positive and negative mass contrasts induced by the δ_w^s and δ_c density Bouguer slabs that apparently take away the sea water and respectively fill the space between the gravity station and the sea bottom with crust density virtual material (Fig. 6).

In the case of **on-bottom gravity measurements** (Fig. 6), the Bouguer anomaly's computation formula is:

$$\Delta g = g_{obs} - [\gamma_0 + \partial\gamma/\partial zh - 2\pi G(\delta_c + \delta_w^s)h - R_s(\Delta\delta^s) - R_t(\delta_t)] \quad (5)$$

which becomes:

$$\Delta g = g_{obs} - \gamma_0 - 0.1535h + R_s(\Delta\delta^s) + R_t(\delta_t) \quad (6)$$

On the other hand, measurements follow strictly the classic terrestrial gravity methodologies on the dry sectors of the transition zones (Fig. 7, case 1). Within lacustrine shallow water zones, e.g. Razelm-Sinoie lagoon complex located in the southern Danube Delta, rough gravity data are acquired mainly by on surface measurements (terrestrial meters on 1 to 3 m height tripods) up to 1.5 ÷ 2 m depth water and by on-bottom measurements (remote controlled gravity meters).

During the gravity data acquisition campaigns, the fresh water level in the investigated area may suffer important changes, due mainly to the Danube River level variation. These facts induce different relations between terrestrial, on surface or on-bottom lacustrine gravity station's level on one hand and the shallow water level and the geodetic ellipsoid's surface on the other hand. In this context, eight different positions of the gravity station in a CSTZ have been pointed out (Fig. 7). The computation of the Bouguer anomaly value has to be made, in each of these cases, by using the proper formula. In order to obtain very useful standardized gravity anomaly maps, the Bouguer correction is recommended to be made, if possible, for a 2.67 g/cm^3 density of the slab's material (i.e. $\delta_t = \delta_c$). Helpful practical formulas will also be presented for each of the eight different cases.

Terrestrial gravity station above the ellipsoid's surface (Fig. 7, case 1) This is the classic case of on land gravity measurements.

$$\Delta g = g_{obs} - [\gamma_0 - \partial\gamma/\partial z z + 2\pi G\delta_t z - R_t(\delta_t) - R_s(\Delta\delta^s)] \quad (7)$$

$$\Delta g = g_{obs} - \gamma_0 + 0.1966z + R_t(\delta_t) + R_s(\Delta\delta^s) \quad (8)$$

Terrestrial gravity station below the ellipsoid's surface (Fig. 7, case 2)

$$\Delta g = g_{obs} - [\gamma_0 + \partial\gamma/\partial z h - 2\pi G\delta_c h - R_t(\delta_t) - R_s(\Delta\delta^f, \Delta\delta^s, \delta_w{}^s)] \quad 9)$$

$$\Delta g = g_{obs} - \gamma_0 - 0.1966h + R_t(\delta_t) + R_s(\Delta\delta^f, \Delta\delta^s, \delta_w{}^s) \quad (10)$$

On surface lacustrine gravity station with the lake's surface and bottom above the ellipsoid (Fig. 7, case 3)

$$\Delta g = g_{obs} - [\gamma_0 - \partial\gamma/\partial z z + 2\pi G\delta_w{}^f a + 2\pi G\delta_t(z-a) - R_t(\delta_t, \delta_w{}^f) \pm R_s(\Delta\delta^f, \Delta\delta^s)] \quad (11)$$

$$\Delta g = g_{obs} - \gamma_0 + 0.1966z + 0.07002a + R_t(\delta_t, \delta_w{}^f) \pm R_s(\Delta\delta^f, \Delta\delta^s) \quad (12)$$

On surface lacustrine gravity station above the ellipsoid with the lake's bottom below the ellipsoid (Fig. 7, case 4)

$$\Delta g = g_{obs} - [\gamma_0 - \partial\gamma/\partial z z + 2\pi G\delta_w{}^f a - 2\pi G(\delta_c - \delta_w{}^f)(a-z) - R_t(\delta_t, \delta_w{}^f) \pm R_s(\Delta\delta^f, \Delta\delta^s)] \quad (13)$$

$$\Delta g = g_{obs} - \gamma_0 + 0.23858z + 0.02809a + R_t(\delta_t, \delta_w{}^f) \pm R_s(\Delta\delta^f, \Delta\delta^s) \quad (14)$$

On surface lacustrine gravity station with the lake's surface and bottom below the ellipsoid (Fig. 7, case 5)

$$\Delta g = g_{obs} - [\gamma_0 + \partial\gamma/\partial z h - 2\pi G\delta_c h - 2\pi G(\delta_c - \delta_w{}^f)a - R_t(\delta_t) \pm R_s(\Delta\delta^f, \Delta\delta^s)] \quad (15)$$

$$\Delta g = g_{obs} - \gamma_0 - 0.1966h + 0.07002a + R_t(\delta_t) \pm R_s(\Delta\delta^f, \Delta\delta^s) \quad (16)$$

On-bottom lacustrine gravity station above the ellipsoid (Fig. 7, case 6)

$$\Delta g = g_{obs} - [\gamma_0 - \partial\gamma/\partial z z - 2\pi G\delta_w{}^f a + 2\pi G\delta_t z - R_t(\delta_t) \pm R_s(\Delta\delta^f, \Delta\delta^s, \delta_w{}^f)] \quad (17)$$

$$\Delta g = g_{obs} - \gamma_0 + 0.1966z + 0.04193a + R_t(\delta_t) \pm R_s(\Delta\delta^f, \Delta\delta^s, \delta_w{}^f) \quad (18)$$

On-bottom lacustrine gravity station below the ellipsoid with the lake's surface above the ellipsoid (Fig. 7, case 7)

$$\Delta g = g_{obs} - [\gamma_0 + \partial\gamma/\partial z h - 2\pi G\delta_w{}^f a - 2\pi G\delta_c h - R_t(\delta_t) \pm R_s(\Delta\delta^f, \Delta\delta^s, \delta_w{}^f)] \quad (19)$$

$$\Delta g = g_{obs} - \gamma_0 - 0.1966h + 0.04193a + R_t(\delta_t) \pm R_s(\Delta\delta^f, \Delta\delta^s, \delta_w{}^f) \quad (20)$$

On-bottom lacustrine gravity station with the lake's surface and bottom below the ellipsoid (Fig. 7, case 8)

$$\Delta g = g_{obs} - [\gamma_0 + \partial\gamma/\partial z h - 2\pi G\delta_w{}^f a - 2\pi G\delta_c h - R_t(\delta_t) - R_s(\Delta\delta^f, \Delta\delta^s, \delta_w{}^s)] \quad (21)$$

$$\Delta g = g_{obs} - \gamma_0 - 0.1966h + 0.04193a + R_t(\delta_t) + R_s(\Delta\delta^f, \Delta\delta^s, \delta_w{}^s) \quad (22)$$

The terms situated between the normal gravity term (γ_0) and the terrain correction terms (R_t, R_s), are usually conveniently gathered into an elevation correction that is independently computed.

A careful examination of the before mentioned

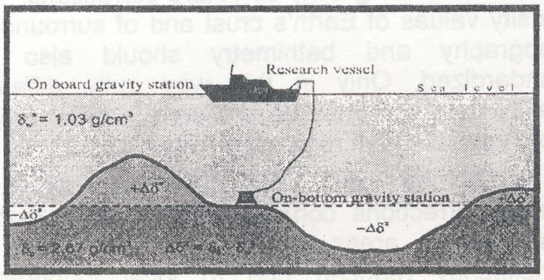

Fig. 6 Marine gravity measurements

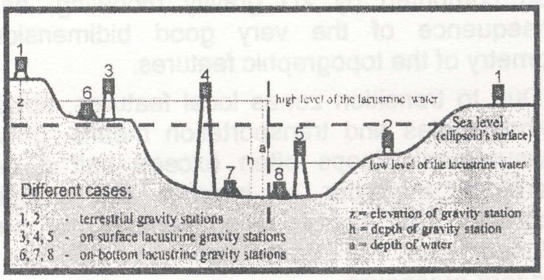

Fig. 7 Continent-sea transition zone gravity measurements. Eight different cases

Bouguer anomaly computation formulas points out that the gravity effects induced by emerged topography are always negative. Therefore the corresponding terrain corrections will be positive in all cases. On the contrary, in the case of on-board gravity measurements and also for the most cases of gravity measurements in CSTZ, the gravity effects due to submerged landscape can be both positive and negative. This is caused by the positive and also negative mass contrasts induced around the gravity station by topographic (Bouguer) reduction application. Therefore the corresponding terrain corrections will be both positive and negative.

Usually, the difference between the main sea level and the lacustrine water level ranges within a few decimeters. The water depth of lagoons and lacustrine basins varies usually between zero and a few meters and the bathimetry variations are also very low. Therefore the corresponding terrain corrections are small, even negligible, for most cases.

The computation of the terrain corrections should be made according to standard procedures, up to standardized distances, such as 20 or 30 km, around each gravity station and the gravity curvature (Bullard B) correction up to 166.7 km should be also considered. LaFehr (1991-b) and Whitman (1991) present rapid and most accurate solutions for the gravity curvature corrections. The density values of Earth's crust and of surrounding topography and bathimetry should also be standardized. Only in this way quite different gravity data sets may be gathered in order to get most valuable high regional gravity maps.

Sometimes within a CSTZ the computation of terrain corrections corresponding to inner zones (surrounding areas up to 100 m) may be consistently reduced due to local topography features. For instance, in case of terrestrial gravity measurements performed in the Danube Delta along the main banks and spits, that are bordered or not by lakes and natural or excavated channels, very accurate inner zone terrain corrections have been computed by 2D gravity modeling, as a consequence of the very good bidimensional geometry of the topographic features.

Due to transition zones local features, applied methodologies and transportation means, gravity measurements loops often exceed half a day. Therefore, in order to improve the mapping accuracy, it's highly recommended to have included also the Earth tide reduction as a standard procedure.

CONCLUSIONS

The great importance of the CSTZ for the global understanding of the continental shelves deep geological structure and tectonics become more obvious each year. Although the interest for geological and geophysical investigation of these perimeters is constantly increasing, the amount of new data acquired each year is still at a low level. This is caused mainly by the poor applicability of both onshore and offshore standard geophysical methodologies. Specific geophysical surveying methodologies that are developed for these high sensitive areas have to be designed and applied in order to leave no footprints and in a full respect for local populations, habitats and ecosystem's health.

The fractal dimension analysis of all available data sets, prior to perform any data acquiring, is very helpful for the planned measurements network design and for the survey's gross cost estimation. The input of randomly distributed data into regular networks should be properly made, with the optimum gridding interval, as a consequence of such a statistical analysis.

The high specificity of CSTZ local conditions yields to different relations between some key parameters of gravity calculation, such as the water depth and the elevation or the depth of the gravity station with respect to geodetic ellipsoid's surface. For each of the previously pointed out cases, a different Bouguer anomaly computation formula has to be applied. A special attention has also to be granted, in each case, to terrain correction computation.

Gravity data acquired with quite different methodologies and accuracy onshore, offshore or in CSTZ are finally stocked in large geophysical databases. Data belonging to different data sets afterwards become subject of changes between data banks and are gathered and computed together in order to obtain gravity anomaly maps of extended areas. These processes would be possible only if original data were properly computed and each step and parameter of computation were recorded in a detailed label for each data set. Therefore a standardized procedure of Bouguer anomaly computation is more then ever recommended.

REFERENCES

AIRINEI, S., SUCEAVĂ, M., 1964, Notă asupra anomaliei gravimetrice-magnetice din regiunea lacului Sinoie (Dobrogea): D.S. Com. Geol., 50, 2, 445-451.

AIRINEI, S., 1968, Măsurători gravimetrice-magnetometrice în Delta Dunării pentru hărțile geofizice ale Romaniei: D.S. Inst. Geol., 53, 3, 411-427.

BOTEZATU, R., BĂCIOIU, T., 1957, Anomalia gravității în Dobrogea Centrală: Bul. Şt., S. Geol., Geogr., 2, 2, 237-252.

DIMITRIU, R.G., SAVA, C.S., Maran, C., 1992, Contribuții metodologice la cartarea gravimetrică a zonelor lacustre și marine cu ape puțin adânci: St. Cerc. Geof., 30, 53-60.

DIMITRIU, R.G., 1995, Aportul gravimetriei la precizarea raporturilor cuvertură sedimentară/fundament în Delta Dunării. Impactul ecologic al lucrărilor gravimetrice: An. St. ICPDD Tulcea, 4, 2, 35-48.

DIMITRIU, R.G., EUFROSIN, C.G., 1995, Optimized gridding and interpolation of the on/offshore Romanian coast gravity data set as deduced by it's fractal dimension analysis: Romanian Geophysics, 2, paper C9.

DIMITRIU, R.G., EUFROSIN, C.G., 1997, The structural frame at the boundary between the Moesian Platform and the North Dobrogea Orogen. Gravity and magnetics in the continent-sea transition zone:

Istanbul, Turkey, Int. Geophys. Conf. & Exp., Technical Program Abstracts, 100-101.

KEATING, P., 1993, The fractal dimension of gravity data sets and its implication for gridding: Geophysical Prosp., 41, 8, 983-993.

LAFEHR, T.R., 1991-a, Standardization in gravity reduction: Geophysics, 56, 1170-1178.

LAFEHR, T.R., 1991-b, An exact solution for the gravity curvature (Bullard B) correction: Geophysics, 56, 1179-1184.

SAVA, C.S., 1985, Prime rezultate ale cercetărilor gravimetrice marine de bord pe platoul continental românesc al Mării Negre: St. Cerc. Geol. Geof. Geogr., S. Geof., 23, 29-33.

WHITMAN, W.W., 1991, A microgal approximation for the Bullard-B-Earth's curvature gravity correction: Geophysics, 56, 1980-1985.