TWO-DIMENSIONAL MASS DISTRIBUTION FROM GRAVITY ANOMALIES SOUTH EL ARISH AREA

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ABSTRACT. — In this paper, the surface bounding the anomalous masses at depth has been discussed. Different methods and techniques for such studies are used, ranging from graticules to the non-linear optimisation techniques making use of high-speed computers for the complete solution of the given problems, after a great number of iterations. The determined surface is in harmonic relation with those computed upon analyzing the vertical magnetic intensity anomalies in this region.

INTRODUCTION

It is well known that the structure of the subsurface anomalous masses is of utmost importance. Our problem is to assign or to detect the shape of the boundary line between the basement rocks and the overlying sediments. The profile line describing the end product of the subsurface activities leads to the determination of this structure. Once the shape of the basement surface is determined, the coordination is possible between the structure at this level and those at the surface, for the purpose of enumerating the stress phases affecting the area. To achieve this goal, Bouguer anomaly profile is treated by graticuling technique (Hubbert, 1948), and the techniques of optimisation (Al Chalabi, 1972), in order to clue the question of the basin configuration at the area south of El Arish. The detailed structural picture or the relief in the investigated area of the subsurface anomalous masses in given recently by non-linear optimisation techniques, synthetization of shapes of the anomalous bodies with adjusting the parameters of depth, density contrast, and regional background, or without adjusting any of these parameters.

THEORY AND PROCEDURE

The essential point of this method is to minimize as much as possible the value of the function F, which defines the measure of the discrepancy between the observed and the calculated anomalies. For convenience of representation, this function can be written as follows:

$$F(x) = \sum_{k=1}^{N} (A_k - B - 2G\rho T_k)^2 \quad \ldots\ldots \quad (1)$$

where A_k is the observed anomaly, B is the regional background, G is the universal gravitational constant, r is the density contrast and T_k is given by the equation:

$$T_k = \sum_{i=1}^{N} S_{ik} \quad \ldots\ldots \quad (2)$$

where S_{ik} is the term or function evaluating the position and length of all sides of the model in x-y system, and can be represented as:

$$S_{ik} = L_{i+1}\,(\Phi_2) - L_i\,(\Phi_1)_{ik} - \left[\, \Sigma_i \operatorname{Sin}\Theta_i + L_i \operatorname{Cos}\Theta_i \,\right] \left[\, \operatorname{Sin}\Theta_i \log\,(r_2/r_1)_{ik} + \operatorname{Cos}\Theta_i \left\{ (\Phi_2)_{ik} - (\Phi_1)_{ik} \right\} \right] \quad (3)$$

for M-sided polygon, the function T_k can be evaluated by the described procedure.

For the cases of undefined parameters (regional background, depth and the density contrast), Al Chalabi (1972) formulae are extended to include such cases, where B (regional background) is given by the relation:

$$B = \frac{I}{N}\left[\sum_{k=1}^{N} A_k - 2G\rho \sum_{k=1}^{N} T_k\right] \quad (4)$$

N is the number of points of observation. On the other hand, r (density contrast) can be expressed as:

$$\rho = N\left[\sum_{k=1}^{N} A_k T_k - \left(\sum_{k=1}^{N} A_k\right)\left(\sum_{k=1}^{N} T_k\right)\right] / 2G\left[N\sum_{k=1}^{N} T_k^2 - \left(\sum_{k=1}^{N} Tk\right)^2\right] \quad (5)$$

However, the determination of the discrepancy of the calculated field from the observed one is very important. The minimization of its value is of utmost importance.

Our problem can be treated as two separate anomalies suggesting two adjacent subsurface masses. The first one is Ras El Ahmar maximum gravity anomaly, and the second is the Libni and South El Halal maximum gravity anomaly. The two anomalies are treated at first without defining or adjusting any controlling parameter, and this, of course, is accompanied by high values of residuals. The following iterations are made introducing the possible parameters which end up with the detailing of the model shape in the last iteration. Such detailing is made at the points where the producing residuals are of higher magnitudes.

On the basis of the above discussion, a careful programming of the well-assigned problem leads after a number of iterations to almost the same (nearly fitted) anomalies.

As stated, the problem is well-assigned, and so also the probable parameters such as depth of the first points of the proposed models, the density contrast, and the regional background. If, however, the parameters are not well-defined, formulae (4 and 5) of the regional and the density contrast, are used. The output data can be taken as adjustable parameters in calculating the objective funciton (F).

APPLICATIONS AND RESULTS

The following areas are exposed to such critical analysis owing to their structural situation:

I. Ras El Ahmar structural high

The proposed model from the gravity profile across the area of Ras El Ahmar is shown in Fig. I *.a.* The adjustment of the depth (Fig. I *.b.)* shows less residual anomaly values than those obtained or calculated in the first step. Density contrast (r) defined by equation (5) is introduced into the parameters used in the above iteration, and different residual amplitudes can be obtained relative to the number of density contrasts used. The suitable one is produced by a minimum value of residuals. For the reduction of the residual amplitudes, especially at the corners of the proposed model, the detailing of such model is the optimum solution as shown from the amplitudes of the residual gravity (Fig. I.c). The following tables give the results of the different steps:

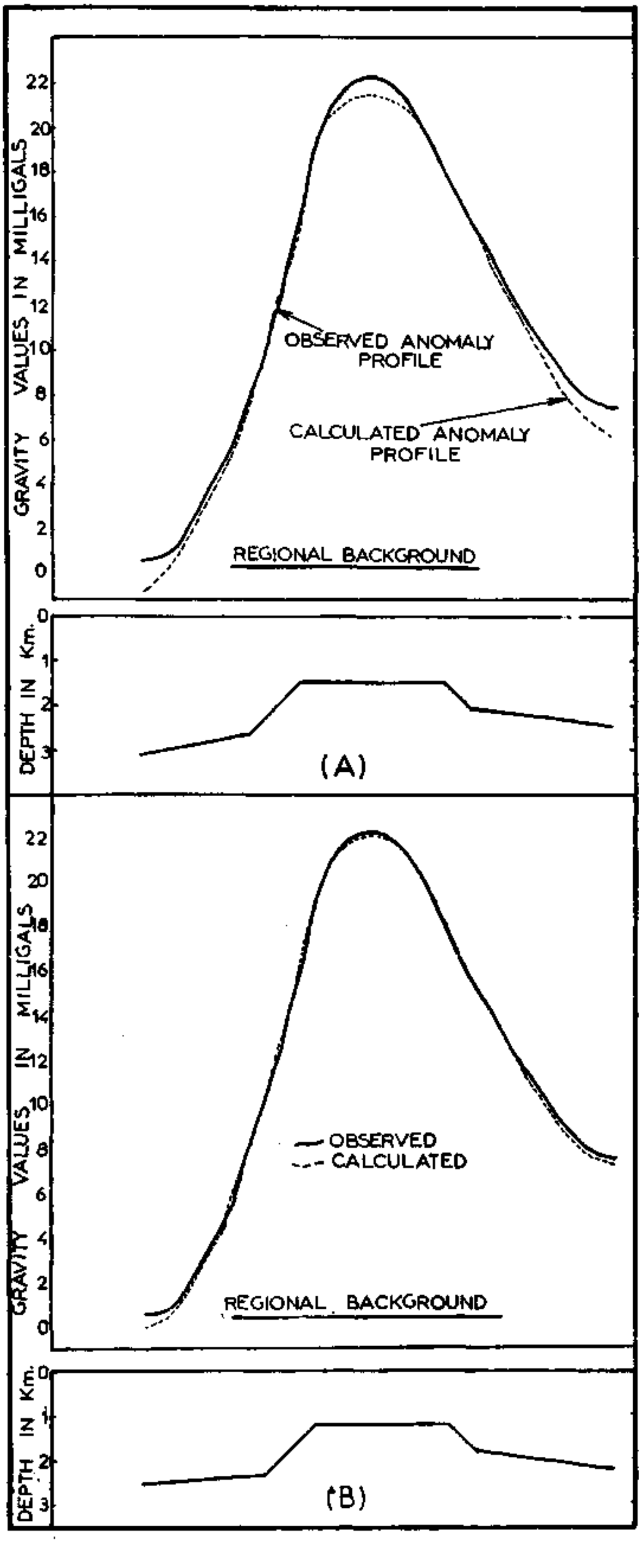

Fig. 1a - Interpreted model of Ras El Ahmar buried structure.
A - Basic model; B - With specifying the depth to the top.

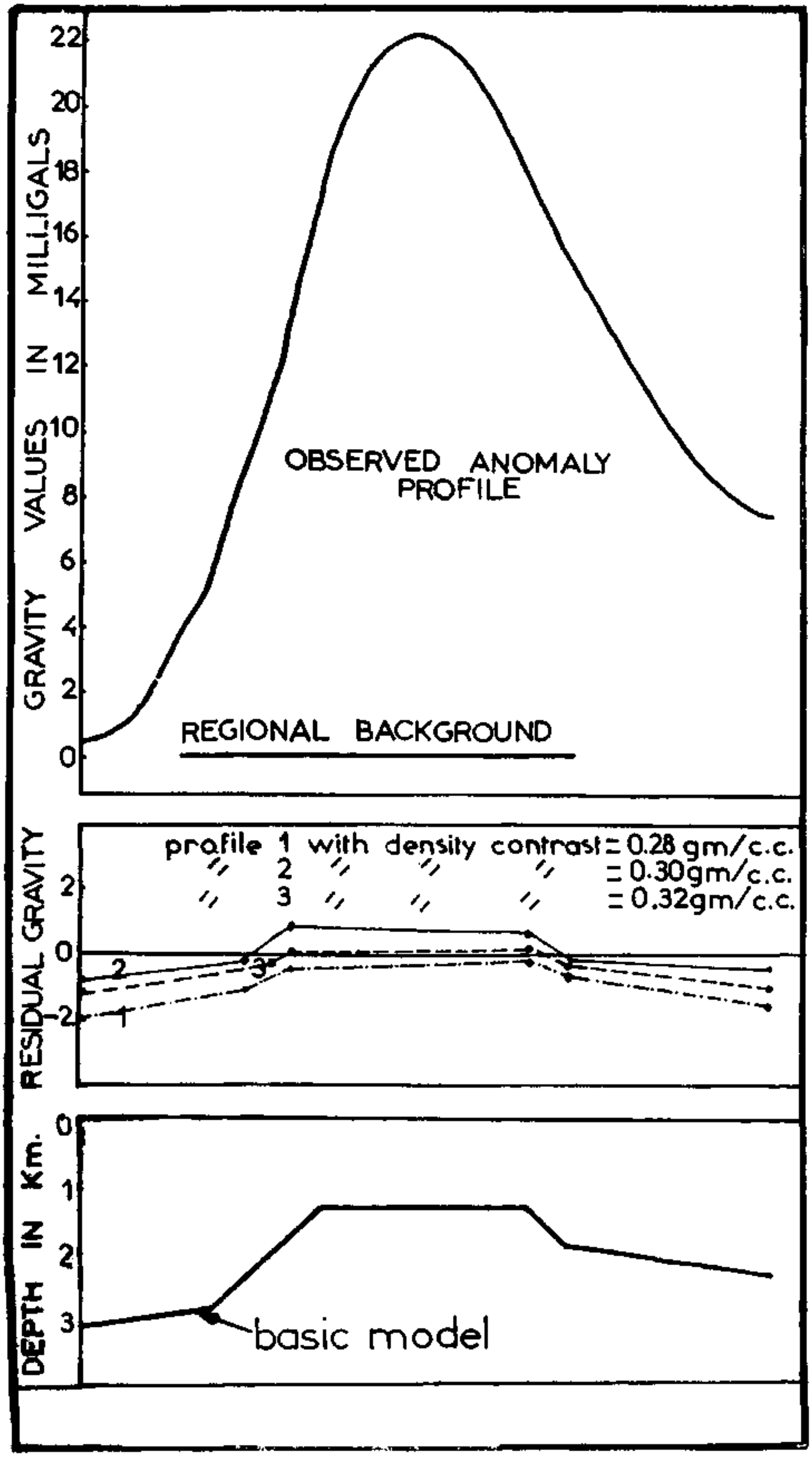

Fig. 1b - Interpreted model of Ras El Ahmar buried structure (with specifying depth and regional background).

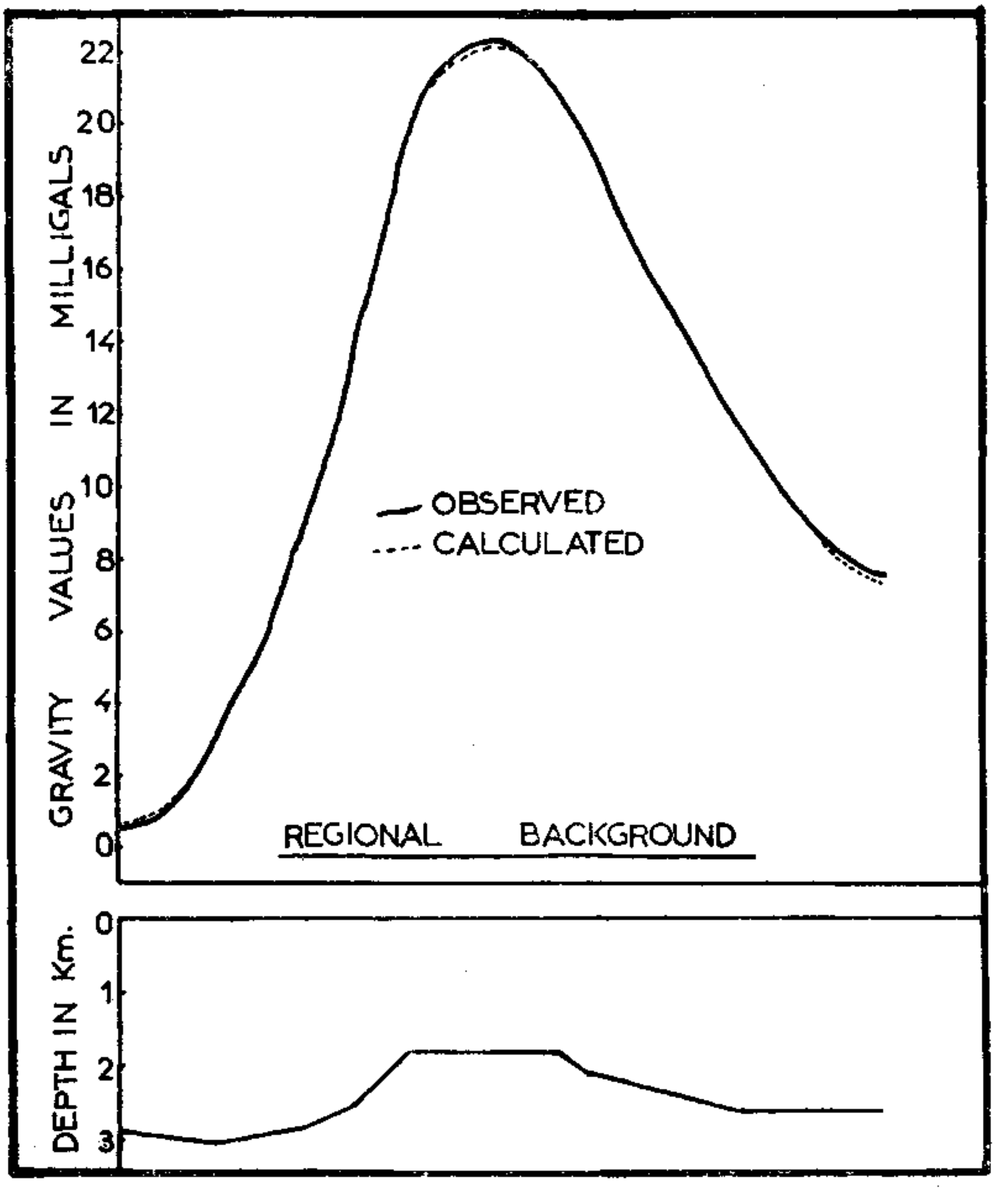

Fig. 1c - Detailing of the basic model of Ras El Ahmar buried structure (with specifying all parameters).

Table - 1.a

First iteration without adjusting any parameter

Corner no.	1	2	3	4	*Total amplitude of residual anom.*
Residual gravity in milligals	— 0.81	— 0.26	— 0.22	— 1.24	+ 1.02 mgal
Computed regional anomaly	20.7	20.7	20.7	20.7	

Table - 1.b

Second iteration with specifying the depth of the first point

Corner no.	1	2	3	4	*Total amplitude*
Residual gravity anomaly	— 0.21	+ 0.45	0.46	— 0.41	+ 0.87 mgal
Computed regional anomaly	20.7	20.7	20.7	20.7	

Table - 1.c

Third iteration with specifying density contrast

Density contrast in mg/c.c.	*Residual gravity values in milligals* 1	2	3	4	*Total amplitude*
0.28	— 0:53	— 0.67	— 0.32	— 1.25	0.93 mgal
0.30	— 0.49	+ 0.26	+ 0.21	— 0.56	0.82
0.32	— 0.55	— 0.13	— 0.13	— 1.67	1.54
Regional background in mgal	20.7	20.7	20.7	20.7	

The residual amplitude given by applying density contrast of 0.30 gm/c.c. is the smaller one (0.82 mgal), for that the last iteration is made with the specified depth, regional background, and the density contrast just obtained. The last iteration is that of detailing of the basic model at the corners of high residuals. More sides are added and the resulted residuals are shown in the following table:

Table - 1.d

Residual gravity by adjusting all parameters

Corner no.	1	2	3	4	5	6	7	*Total amplitude in milligals*
Residual gravity in milligals	— 0.42	— 0.18	— 0.16	+ 0.21	+0.20	0.0	—0.21	0.63
Regional background in milligals	21.6	21.6	21.6	21.6	21.6	21.6		

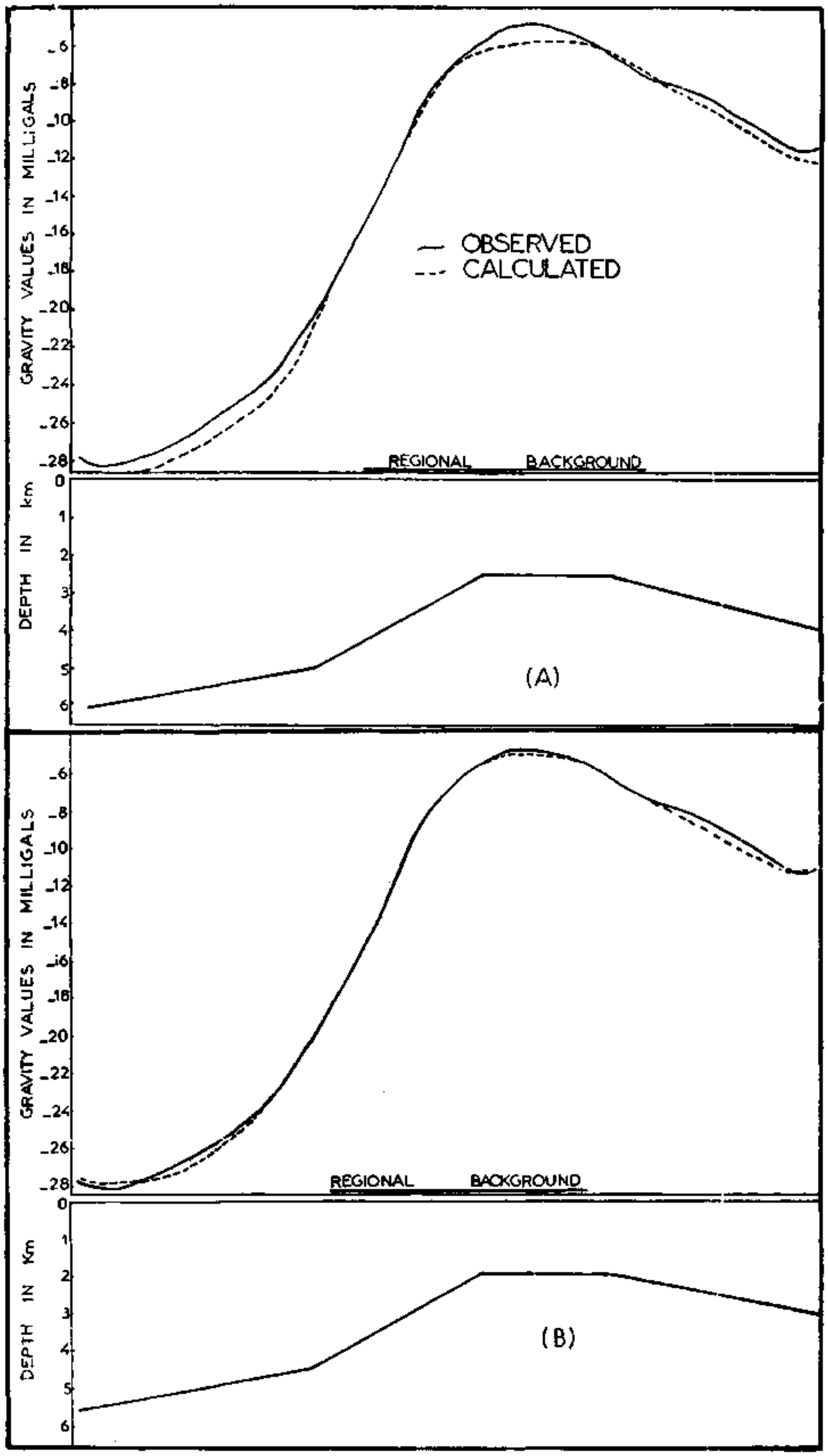

Fig. 2a - Interpreted model of Libni and Southwest El Halal buried structure.
A - Basic model; B - with specifying depth to the top.

2. Libni Southwest El Halal structural high

The gravity profile in this area is interpreted structurally as shown in Fig. 2.a. The computed parameters are specified in the following steps in order to minimize the residual gravity. The results of each iteration are shown in the following table:

Table - 2.a

First iteration without specifying any parameter

Corner no.	1	2	3	*Total amplitude in milligals*
Residual value	— 1.32	— 0.86	— 0.20	1.12
Regional background in milligals	21.2	21.2	21.2	

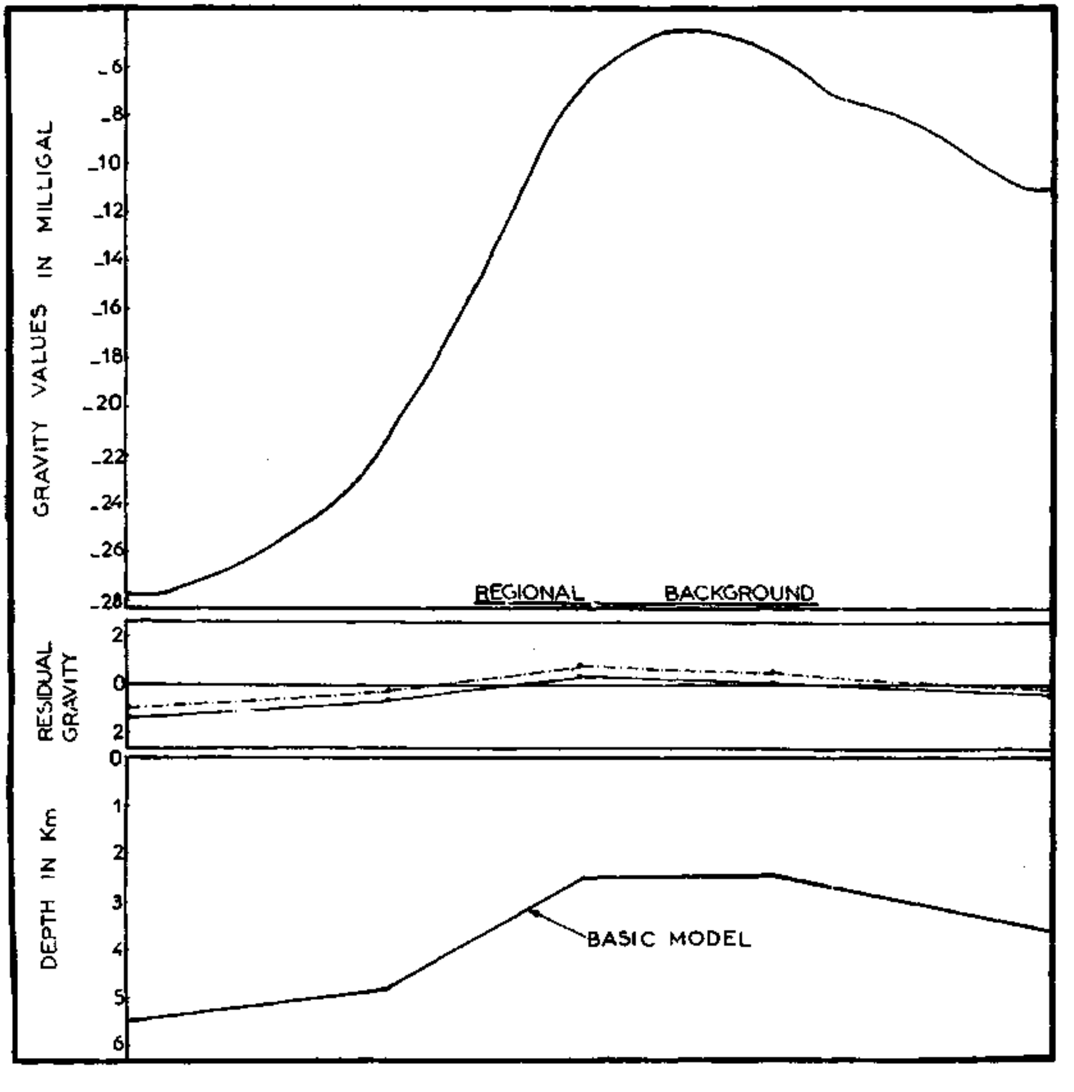

Fig. 2b - Interpreted model of Libni and Southwest El Halal buried structure (with specifying depth and regional background).

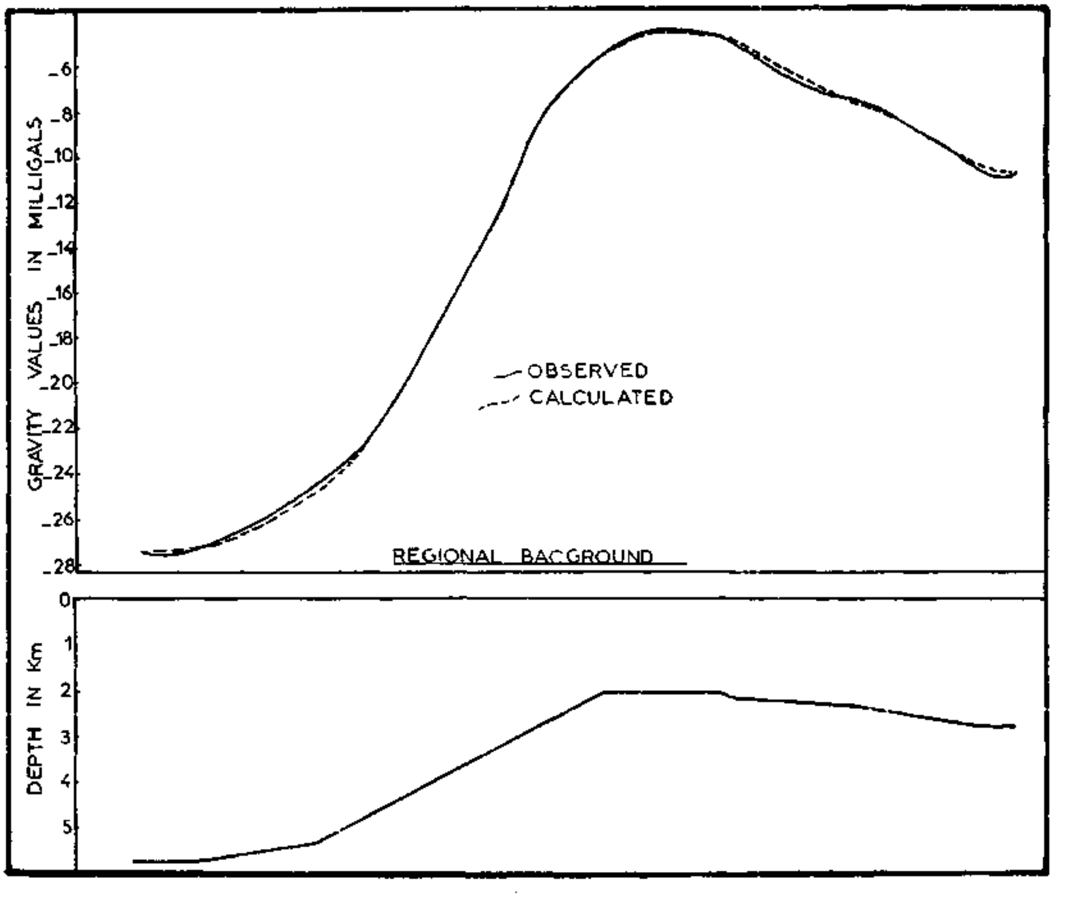

Fig. 2c - Detailing of the model of Libni and Southwest El Halal structures (with specifying all parameters).

Table - 2.b

Second iteration with specifying depth of the second tripl at corner 1 first point

Corner no.	1	2	3	*Total amplitude in milligals*
Residual value of milligals	— 0.61	— 0.33	+ 0.26	0.87
Regional background in mgal	21.2	21.2	21.2	

Table - 2.c

Third iteration with specifying depth and density contrast

Corner no. *Density contrast in milligals*	1	2	3	*Total amplitude in milligals*
0.27	— 0.43	+ 0.27	+ 0.58	1.01
0.30	— 0.28	+ 0.55	+ 1.31	1.59
Regional background in mgal	21.2	21.2	21.2	

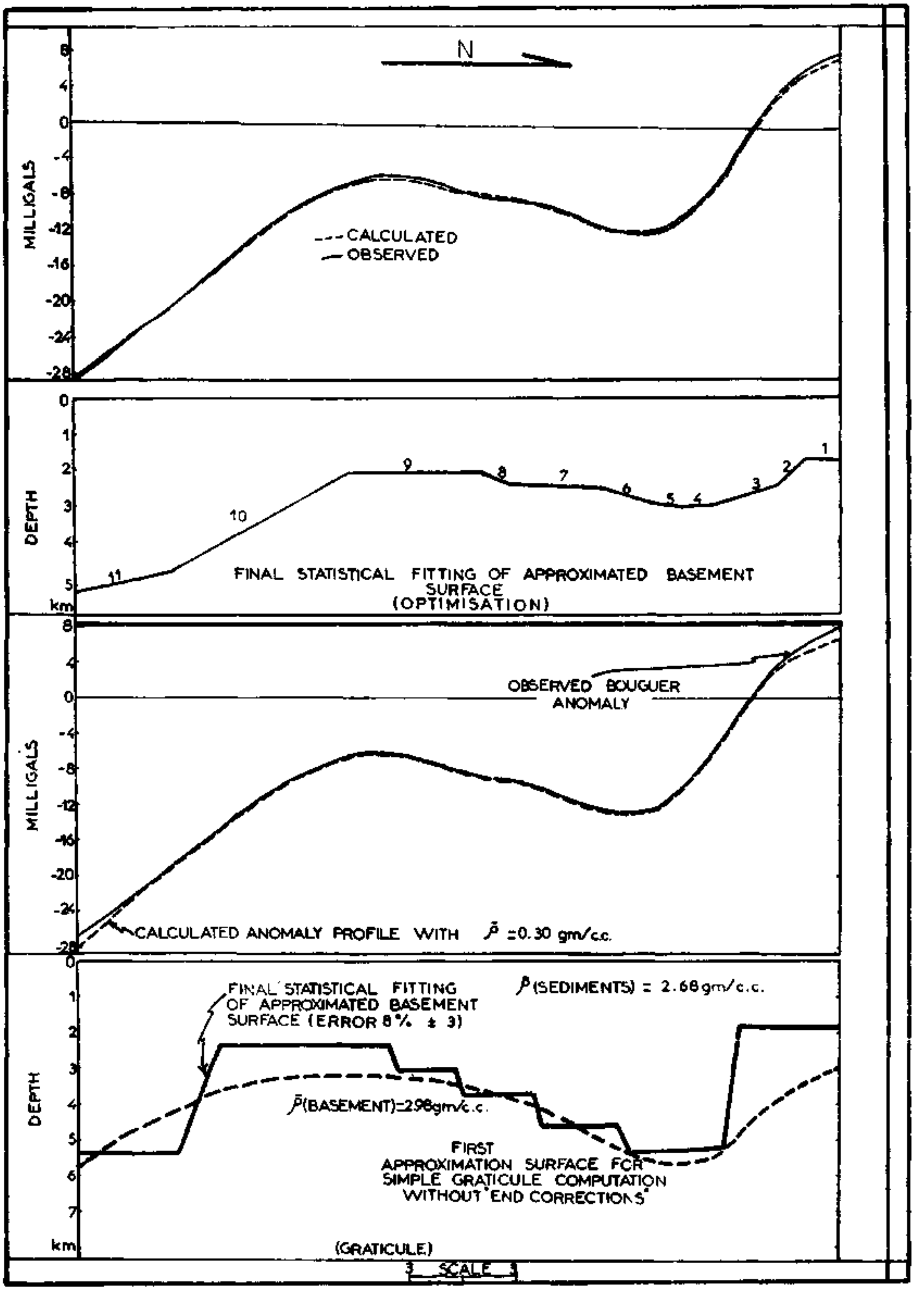

Fig. 3 - Synthetic structure of the basement surface of South El Arish area.

The calculated residual corresponding to the density contrast of 0.27 gm/c.c. is the smallest one. Such a residual value must be minimized and this step can be completed by the detailing of the proposed model in the corners accompanied by high residual values. The following table (2.d.) can show the residual gravity computed after specifying all known parameters:

Table - 2.d

Fourth iteration with specifying all known parameters

Corner no.	1	2	3	4	5	6	*Total amplitude in milligals*
Residual gravity in milligals	— 0.22	— 0.024	+ 0.37	+ 0.26	0.0	+ 0.411	0.65
Regional background in milligals	22.1	22.1	22.1	22.1	22.1	22.1	

In fact the produced residual in the last iteration presents the degree of harmony between the observed gravity anomaly profile and the computed one on the base of the proposed model. This degree becomes larger if the residual field takes minimum values and vice versa. The two cases studied represent a well-defined structure from the analysis of the gravity profiles (Fig. 3).

CONCLUSIONS

In conclusion, gravity profile studied by Al Chalabi (1972) technique introduces another solution of the gravity structural relationship when all parameters are unknown. The above values of the residual field computed show low values in general, and the computed regional backgrounds are accurate within a range of ± l milligal. The coincidence of the results obtained by both trials (for computing the regional background) and the resulting residual field which do not exceed 2 milligals as a total amplitude, give an indication about the validity of such method for the interpretations. On the other hand, the same gravity profile treated by graticuling method, Sabri, and Abd El Rahman (1972), produces the subsurface structural profile nearly the same as that obtained by applying the described technique.

The specified parameter (density contrast) must give the minimum residual values. The use of 0.30 gm/c.c., as contrast in Libni will be accompanied by high residual values. At Ras El Ahmar, however, it gives the minimum value. The valuel of 0.27 gm/c.c. gives minimum residuals at Libni, i.e. the density contrast varies from one place to another showing a decrease from north to south. This result can be confirmed if we know that the basement rocks are shallow at the north and have a great depths at south.

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