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TWO-DIMENSIONAL MODELING TECHNIQUE OF MAGNETIC PROFILES ACROSS THE NORTHERN PART OF THE GULF OF SUEZ USING WERNER DECONVOLUTION METHODS

By

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ABSTRACT

Werner deconvolution method is applied on magnetic anomaly profiles crossing the northern part of the Gulf of Suez. The primary objectives are generally, determinations of the depth and structural configuration of magnetic - like structures. The depth points, dip directions and susceptibility values are compiled by automatic calculation from the magnetic anomaly profiles, which traced in terms of subsurface magnetic structures.

The well known equation for the total magnetic field due to a thin magnetic sheet is programmed to compute automatically the depth to top, susceptibility contrast and dip of these features from a given magnetic field profile.

This technique is applied over five profiles of total magnetic field together with their regional magnetic component along the study area. The results are compared with the geoseismic sections carried out on the same locations. The overall comparison of interpretation was found satisfactory within the same framework of the causative structure, which gives a good evidence on the reliability of applying Werner technique as a simple, cheap and within the framework accuracy of the causative structure.

INTRODUCTION

The fundamental problem in interpretation of magnetic field data is to find out the depth range with certain restrictions of the distribution of magnetic dipoles producing a given anomaly. This ambiguity can be minimized or removed by the assumption of a single geometric configuration of the causative body (i.e. dikes, contact, fault, prism, lens, basementrise, etc.) (Werner, 1974).

Once this assumption has been made, one can then find a unique solution for relevant geologic parameters, such as depth to source, dip and susceptibility.

Pre-computer method of interpretation is discussed in Grant and West (1965), Hartman ***et al*** (1971) and Naudy (1971). An experienced interpreter, armed with a considerable amount of geological knowledge and with enough reasonably isolated anomalies, can do a good job of satisfying the requirements of pre-high sensitivity interpretation. However, when magnetic / geologic conditions are less than ideal, the above methods are subjected to a significant amount of error introducing ambiguity.

The present interpretation technique of magnetic data is an extension of those introduced by S. Werner in 1953. He realized that the greatest need was for a method to separate an anomaly from the interference caused by adjoined anomalies, and also to consider the entire anomaly in his analysis rather than just a few parameters which can be greatly affected by interference of this type.

In Werner deconvolution technique, direct interpretation method, depths, susceptibilities and dips of the causative bodies are analytically determined.

Werner (1953) was mainly concerned with the analysis of mineralized dikes, and hence it is applicable to contacts, edges, faults and other types of bodies.

The method of analysis is applied on given profiles crossing the northern part of the Gulf of Suez , as shown in Fig. (1).

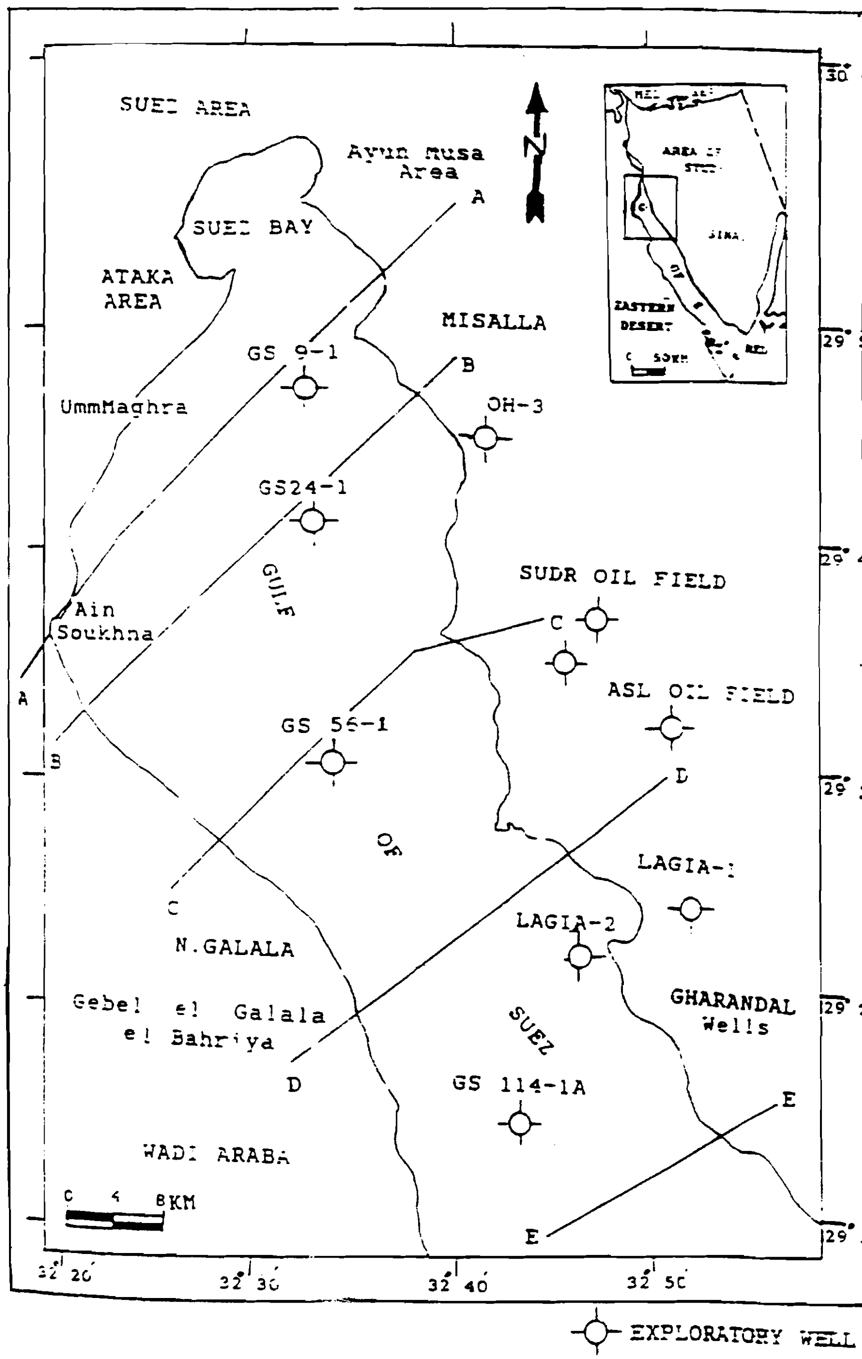

Fig. (1) : The Location Map of The Study Area

THEORETICAL APPROACH:

The equation, in the total field of a dike (thin sheet) can be written in the form:

$$F(x) = \frac{A(x - x_o) + BZ}{(x - x_o)^2 + Z^2} \quad (1)$$

where "x" represent distance along a profile in (km.) and "F" is the total magnetic field, (in gamma), intensity at x. The quantities "A" and "B" are functions of the magnetic properties of the material comprising the sheet-like source (susceptibility) as well as of the position of the sheet in relation to the direction of the earth's normal field. The symbol "Z" represents the depth (in km.) to the top of the dike. and "x_o" is the horizontal coordinate along the traverse of the top of the dike. There are four determining physical quantities; A, B, x_o and Z.

Werner point out that in a simple case where observations are made in a level plane over level-bounded homogeneous sheets of infinite lengths and depths and striking perpendicularly to the direction of the profile, the equation for a dike can be cast into the following interpretation equation:

$$x_2F = a_o + a_1x + b_oF + b_1xF \quad (2)$$

In this equation, "x" and "F" are the same as above and by substitution, it can be seen that:

$$\begin{aligned} a_o &= -Ax_o + BZ \\ a_1 &= A \\ b_o &= -x_o^2 - Z^2 \\ b_1 &= 2x_o \end{aligned} \quad (3)$$

Conversely, the depth and horizontal position of the top of the dike, as well as the magnetization parameters A and B, are functions of the parameters of the interpretation equation (2).

$$x_o = (1/2)\, b_1$$

$$Z = (1/2)\sqrt{(-4b_o - (b_1)^2)}$$

$$A = a_1 \qquad (4)$$

$$B = (2a_o + a_1 b_1) / \sqrt{(4b_o - (b_1)^2)}$$

Since there are four unknown parameters, simultaneous solution of the interpretation equation (2) at four x values and their corresponding F values will yield solutions for a_o, a_1, b_o, b_1 and from equation (4), for x_o, Z, A and B .

Magnetic susceptibility and geologic dip are in turn easily computed from A and B, the Earth's magnetic inclination, declination and assumed sheet thickness.

If we now admit the possibility of interference and assume that it can be represented by a polynomial of some degree, this can be added to equation (1):

$$F(x) = \frac{A(x - x_o) + BZ}{(x - -x_o)^2 + Z^2} + c_o + c_1 x + ... + c^n x^n \qquad (5)$$

where n is the order of the interference polynomial and the c's are coefficients. We now have a total of (n+5) unknowns and therefore (n+5) equations, and (n+5) data points are required to solve for the unknowns. In practice, a first (n = 1) order polynomial is found to be sufficient, so that 6 points are required for solution.

It should be pointed out that the calculation of depth and position is independent of direction of magnetization and is thus unaffected by remanence (Dobrin, 1976; Grant and West 1965).

In practice, the measurements of the magnetic field are made at equal linear interval along a profile line. Therefore, the data are in the ideal form for digital analysis.

In the actual deconvolution, the computer reads six equally spaced point along a profile line (Werner, 1974). It uses the data to solve six simultaneous equations (in F and x) for x_o, Z, A and B (equations 4 & 5).

The entire sequence of points is then advanced by one point (even if the six points used for the calculation are spaced further than one point apart) and another calculation is made for x_o, Z, A and B. In this way, as many x_o and Z pairs are obtained as there are data points along a magnetic profile. Still within in computer, the calculated depth points are examined for consistency. If the six-point operator is passing over an anomaly, there will be a closely grouped set depth point indicating a source for the anomaly. Inconsistent depth calculations are rejected.

Susceptibility and dip values are computed from A and B, local inclination and declination, and the assumption that magnetization is induced. The comfortable depth points are then printed out and recorded, with their corresponding susceptibility and dip values.

RESULTS AND INTERPRETATION

The printout of five profiles of total magnetic and five profiles of regional magnetic component are plotted. These figures are compared with reference seismic sections.

Profile AA`

Study the computed structure model of profile AA`, Fig. (2), shows that:

1. The study area is affected by a set of normal faults, namely; from F_{m1} to F_{m5} from west to east.
2. Comparing the computed section with the seismic section, Fig. (4), reveals the following:

- All the main fault systems in the seismic section appear in thcorresponding computed one.
- The graven structure G_1 in the computed section is clear in seismic section. The magnetic susceptibility contrast of this graben lies in the range $125x10^6$ - $948x10^6$ c.g.s., which indicate that its rocks are of Acidic and Gabbro type.

- The horst H_1 in the computed section is an uplifted structure which is matched with the seismic section. The magnetic susceptibility contrast of his structure lies in the range 342x10^6 - 2679x10^6 c.g.s., i,e it is Rhyolite intrusive body. Thus the area which contains G_1 and H_1 lies within the pre Miocene salt formation and has a continental crust origin.

- The graben G_2 in the computed section is consistence with the seismic section. The magnetic susceptibility contrast of this graben lies in the range 2893x10^6

- 3386x10^6 c.g.s., i.e. this graben is of Basaltic type, a fact indicates that this graben involves new oceanic crust.
- The uplifted structure H_2, appears in the seismic section. The magnetic susceptibility contrast lies in the range 1432x10^6-2772x10^6 c.g.s., which indicates that this uplifted structure consists of Basaltic intrusive body.

- The uplifted structure H_3, in the computed section, is in contradiction with the seismic section.

From the regional magnetic structure model of profile AA`, Fig. (3), a graben structure, G_3, is observed and is matched with the seismic section. The magnetic susceptibility contrast of this graben lies in the range 2772x10^6 - 4220x10^6 c.g.s., which indicates that this graben is of Basaltic origin, due to intrabasement, i.e it constructs new oceanic crust.

- The graben structure, G_3, in the computed section, Fig. (2), is not matched with seismic section. Regional magnetic structure model shows also a graben, G_4, delineatable with two fault planes F_{g5} and F_{g6} which is consistent with the seismic section. The magnetic susceptibility contrast of this graben lies in the range 4220x10^6-7770x10^6 c.g.s., which gives an indication that it is originated from Basaltic intrabasement.
- The uplifted structure, H_3, in the regional magnetic computed section, Fig. (3), is matched with the geoseismic section. The magnetic susceptibility contrast of this structure lies in the range 7770x10^6- 8990x10^6 c.g.s., which indicates that this uplifted structure is originated from Basaltic intrusive body or an intrabasement structure. Generally, one can perhaps conclude that, the structure of the area may be due to birifting process of the Gulf of Suez, which may needs further analysis and criteria.

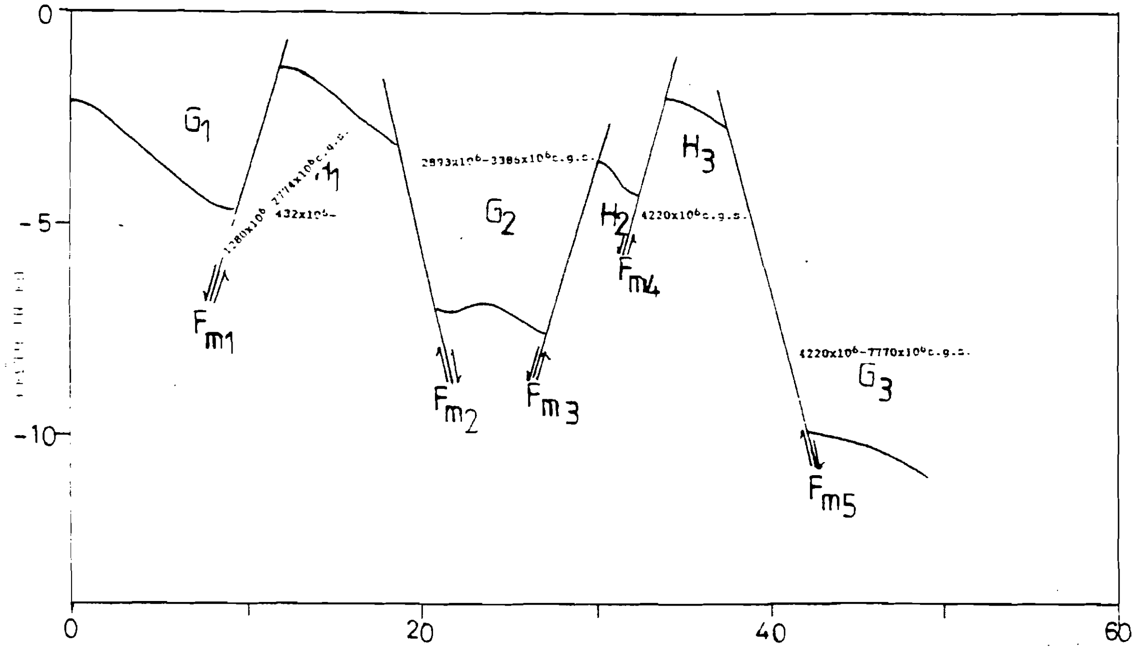

Fig. (2) : Computed Structure Model of Total Magnetic Profile AA`

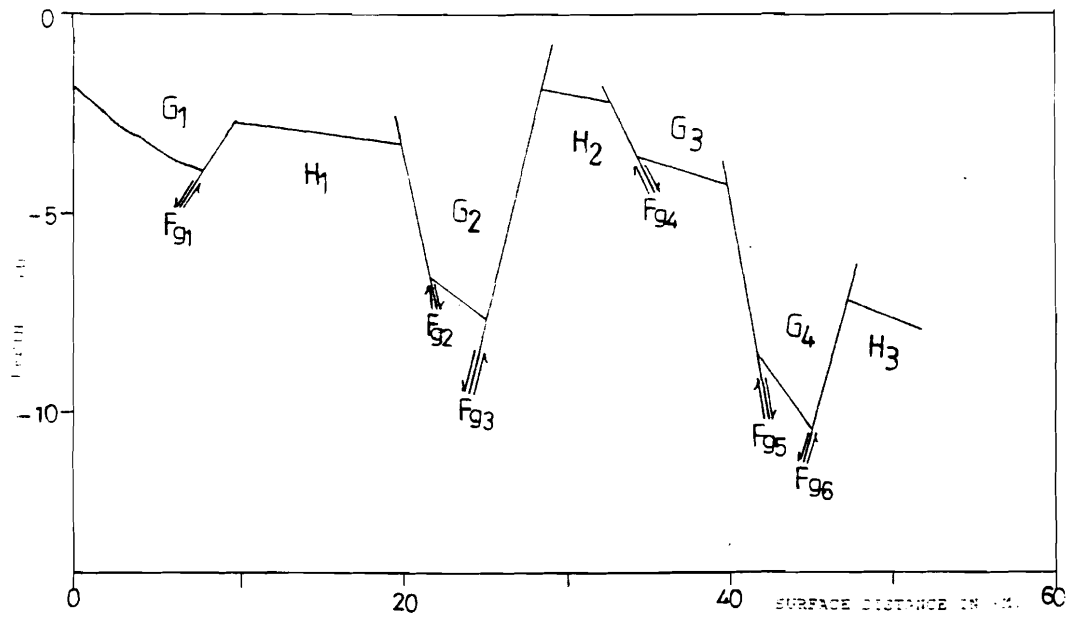

Fig. (3) : Computed Structure Model of Regional Magnetic Profile AA`

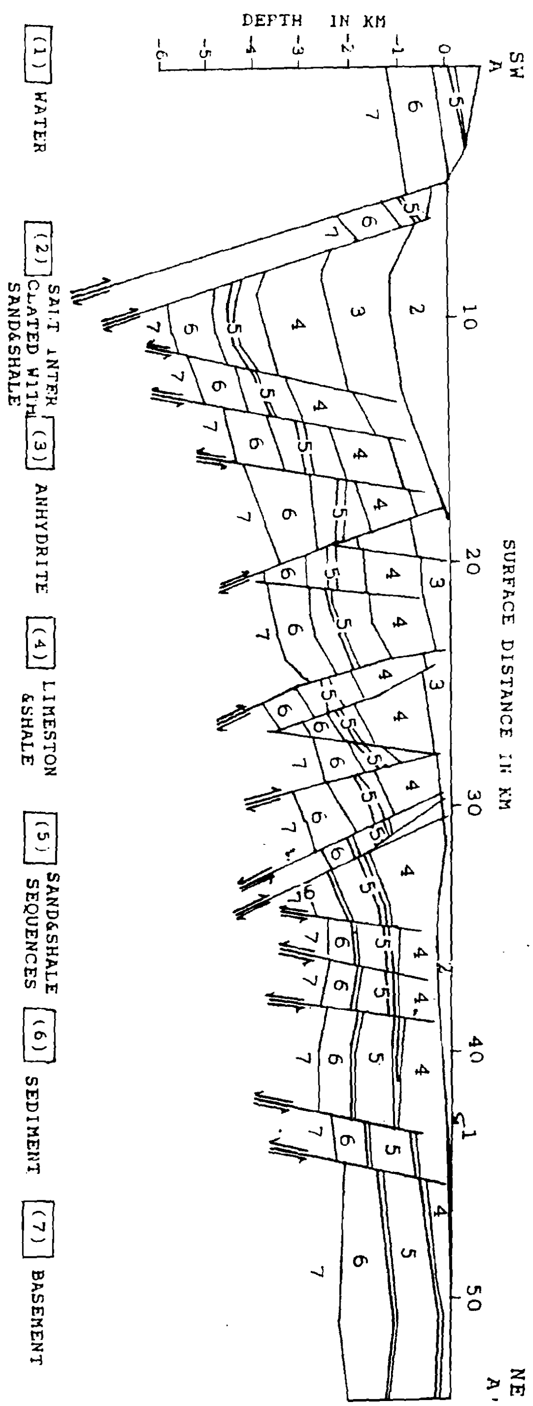

Fig. (4): Reference Seismic Section of Profile AA.

Profile BB`

The computed magnetic structure model of profile BB`, Fig. (5), reveals the following:

1. The study area is affected by a set of normal faults, namely; from F_{m1} to F_{m7} (from west to east).
2. comparing the computed section with the seismic section, Fig.(7), it is noticed that:

- All the main faults system in the seismic section appear in the computed one.
- The graben G_1 in the computed section is present in the seismic section. The magnetic susceptibility contrast lies in the range $27x10^6$ - $990x10^6$ c.g.s., which of Acidic and Gabbro type. Thus, this graben has a continental crust origin.

- The horst H_1 in the computed section is matched with the geoseismic section. The magnetic susceptibility contrast of this horst occupies the range $1247x10^6$ - $1650x10^6$ c.g.s., which indicates that this structure is due Rhyolite intrusive body. Accordingly the area which contains G_1 and H_1 could be originated within the Pre Miocene salt formation.

- The graben G_2 in the computed section is consistent with the seismic section. The magnetic susceptibility contrast of this graben lies in the range $2564x10^6$ - $6890x10^6$ c.g.s., i.e. it is a basaltic intrusive body. The origin of this structure is probably a new oceanic crust.

- The horst, H_2, in the computed section is very clear in the seismic section. The magnetic susceptibility contrast lies in the range $4360x10^6$ - $5857x10^6$ c.g.s., i.e. it is originated from Basaltic rocks of intrabasement.

Profile CC`

Study of computed magnetic structural model of profile CC`, Fig. (8), shows that:

1. The area is affected by a set of normal faults, namely; from Fm_1 to Fm_7, (from west to east).
2. Comparing the computed section, Fig. (8), with the seismic section of profile CC`, Fig. (10), reveals the following:

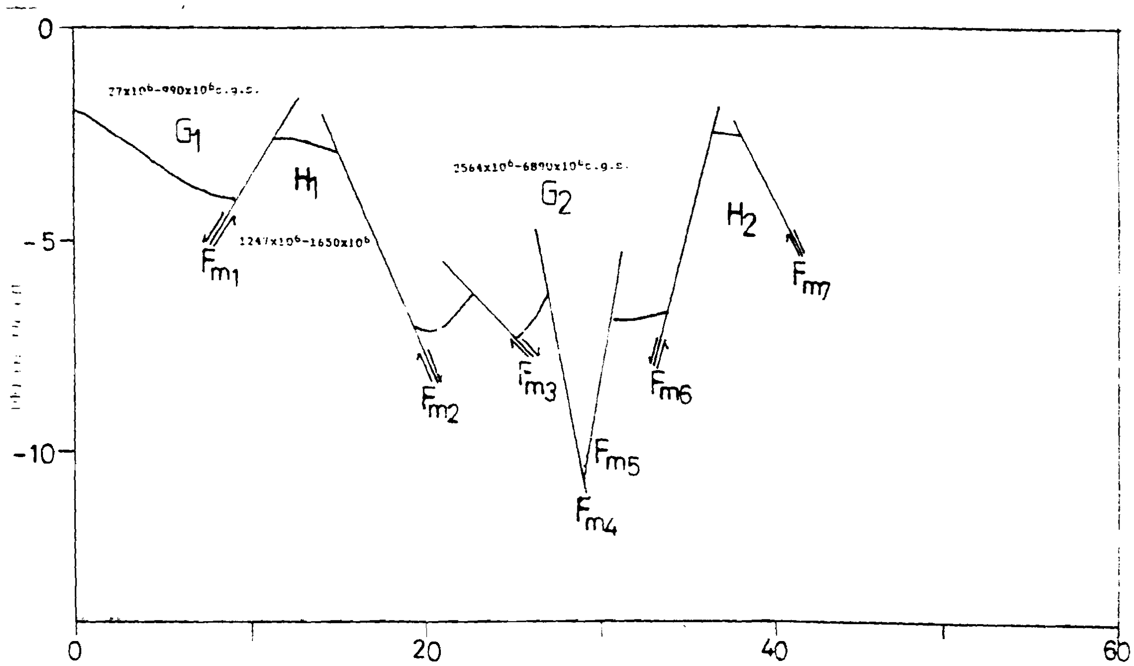

Fig. (5) . Computed Structure Model of Total Magnetic Profile BB`

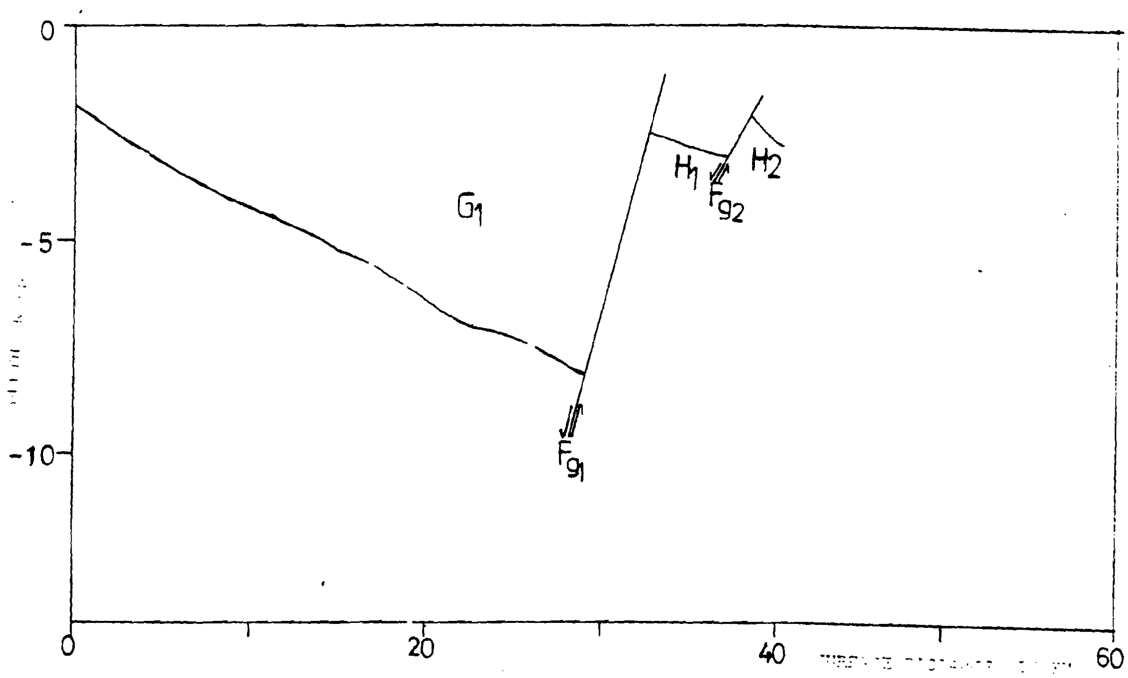

Fig. (6) : Computed Structure Model of Regional Magnetic Profile BB`

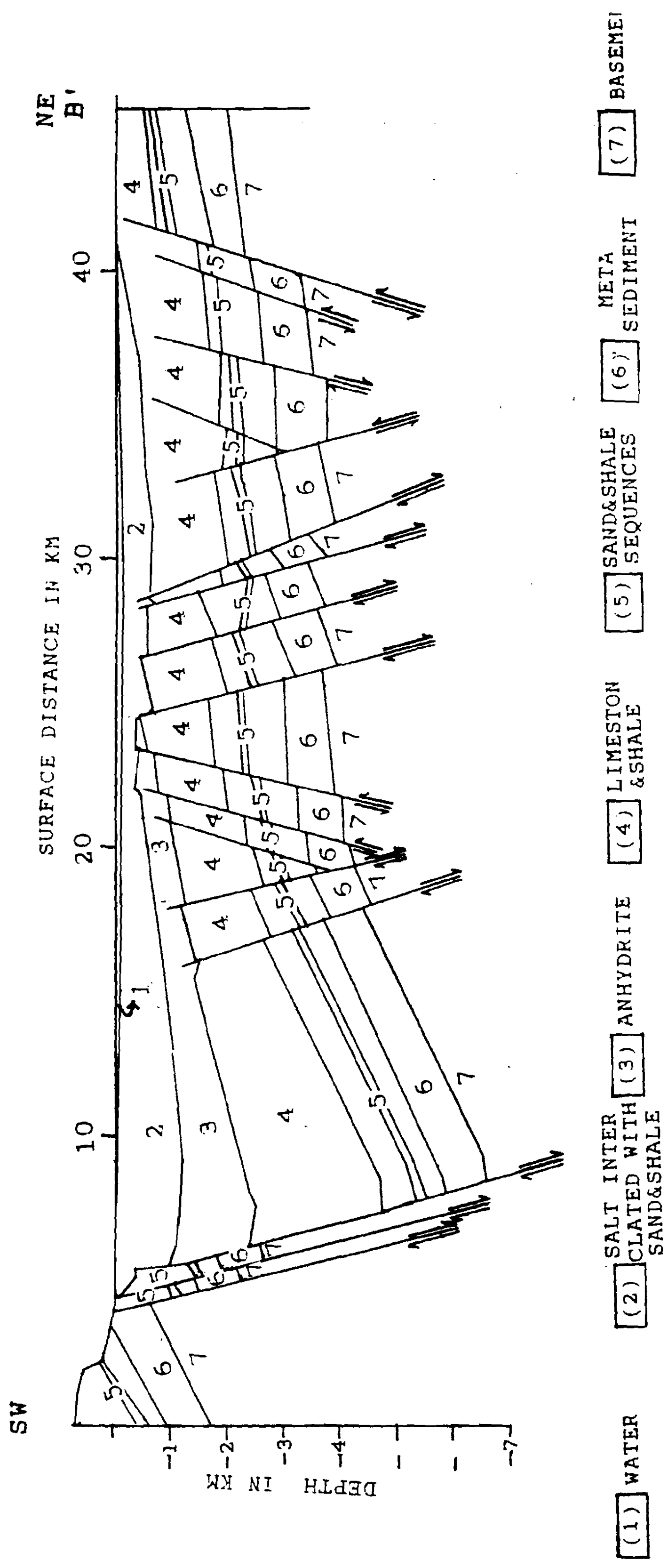

Fig. (7): Reference Seismic Section of Profile BB

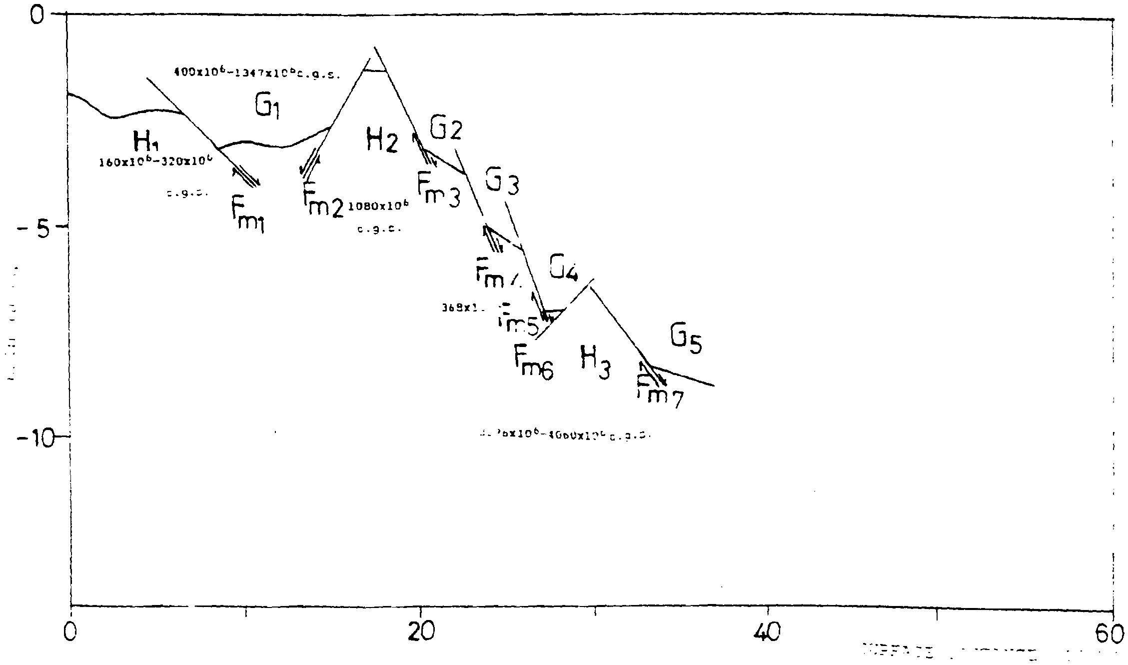

Fig. (8) : Computed Structure Model of Total Magnetic Profile CC`

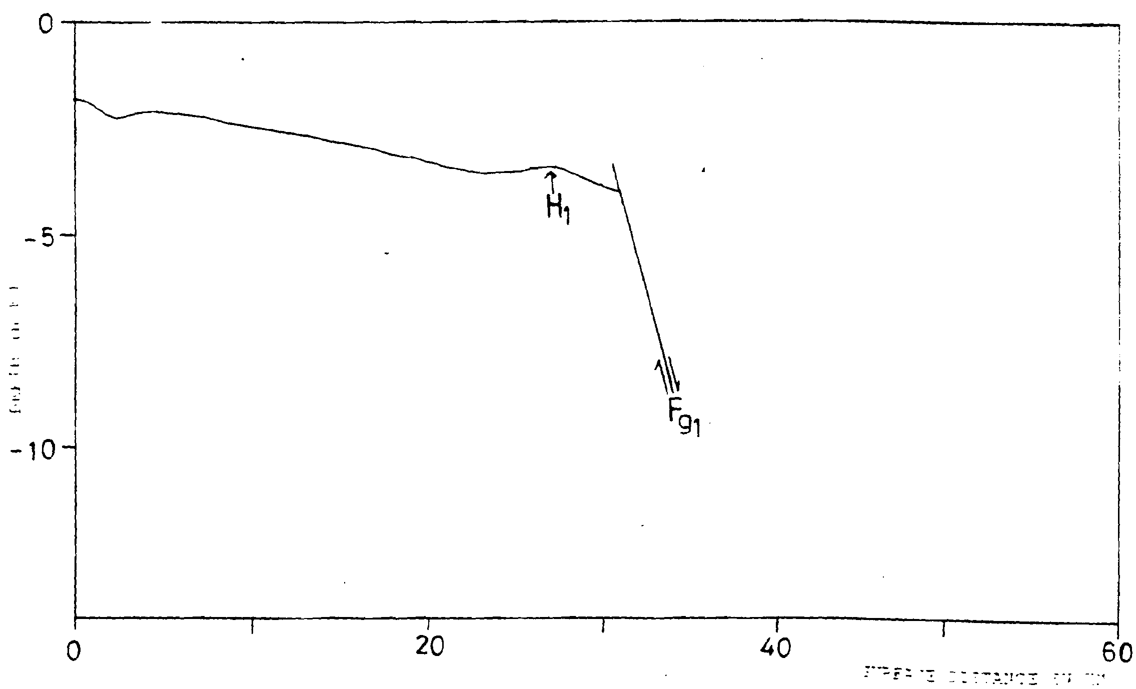

Fig. (9) : Computed Structure Model of Regional Magnetic Profile CC`

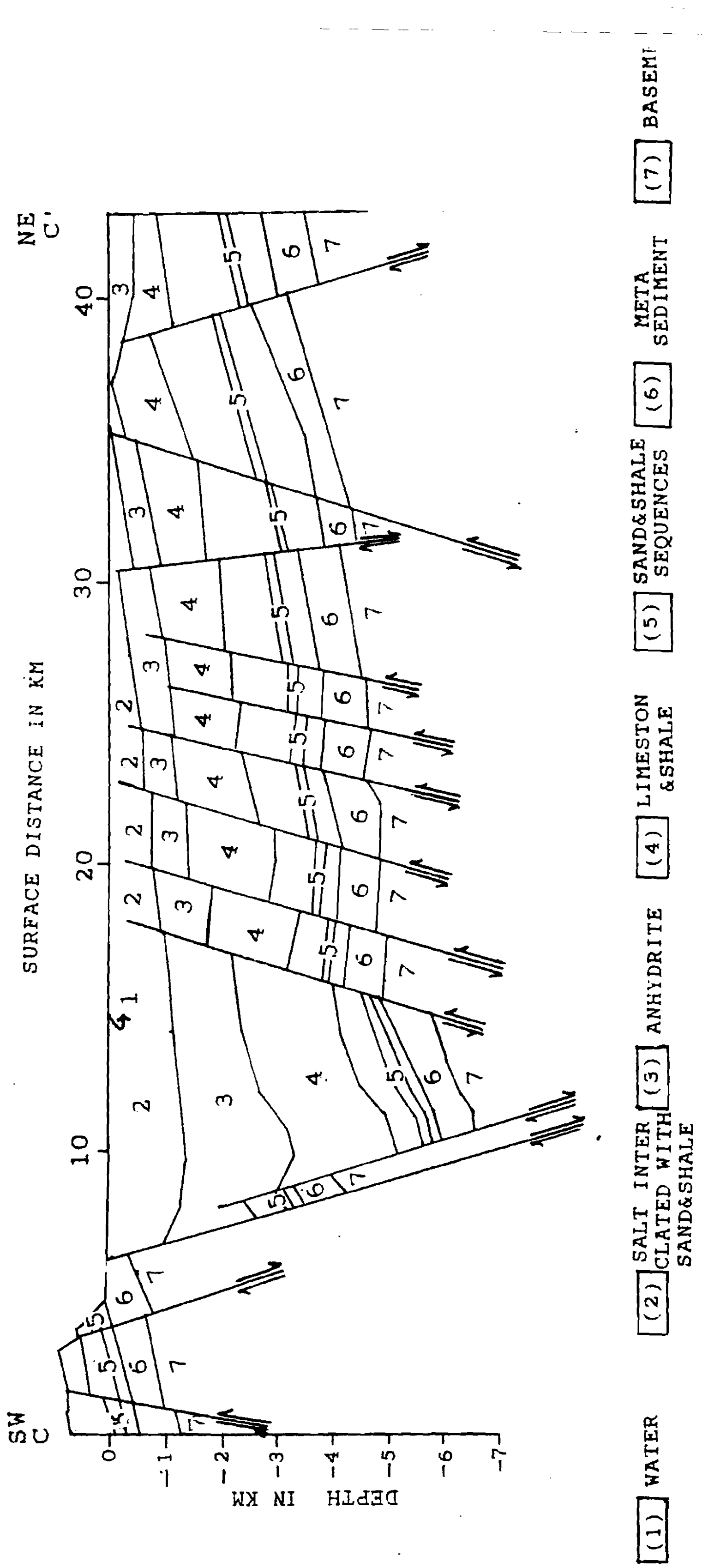

Fig. (10): Reference Seismic Section of Profile CC

- The horst H_1, in the computed section, is matched with the seismic section. Its magnetic susceptibility contrast lies between $160x10^6$ c.g.s. and $320x10^6$ c.g.s., i.e. it is an Acidic intrusive body.

- The graben G_1 in the computed section is consistent with the same one in the seismic section. The magnetic susceptibility contrast of this graben lies between $400x10^6$ c.g.s. and $1347x10^6$ c.g.s., which indicates that it is probably of Granitic and Rhyolite intrusive body.

- The horst H_2 in the computed section appears in the seismic section, but occupying a wide range more than in the computed one. The magnetic susceptibility contrast lies in the range $368x10^6$ - $1080x10^6$ c.g.s., which indicates it is of Acidic intrusive body. Then, we can see that, the area which contains the graben G_1 and the horsts H_1 and H_2 in the computed section is probably constructed within Pre Miocene salt formation and has a continental crust origin.

- The grabens G_2, G_3 and G_4 in the computed section appear as one graben in seismic section. The magnetic susceptibility contrast occupies the range $578x10^6$ - $3492x10^6$ c.g.s., i.e. it is due to Rhyolite intrusive body which is probably originated from new oceanic crust.

- The horst H_3 in the computed section is matched with the corresponding one in the seismic section. The magnetic susceptibility contrast of this horst lies in the range $3699x10^6$- $4060x10^6$ c.g.s., which indicates Basaltic rocks. Then, it is of oceanic crust origin.

-The graben G_3 in the geoseismic section does not appears in the computed one.

Profile DD`

General view of the computed magnetic model of profile DD`, Fig. (11), gives good consistency with the seismic section, Fig. (13).

Careful study of the computed magnetic structure model shows that:

1. The study are is affected by two normal faults, namely; F_{m1} and F_{m2}.
2. Comparison between the computed section, Fig. (11), and the seismic section, Fig. (13), indicates that:

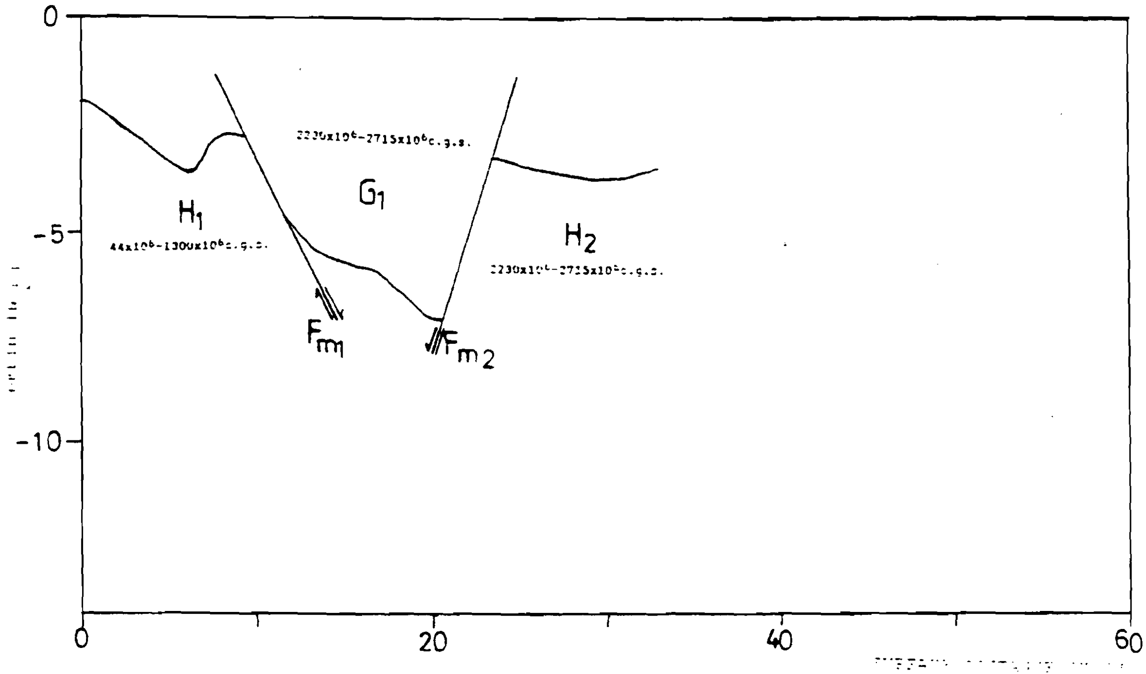

Fig. (11) : Computed Structure Model of Total Magnetic Profile DD`

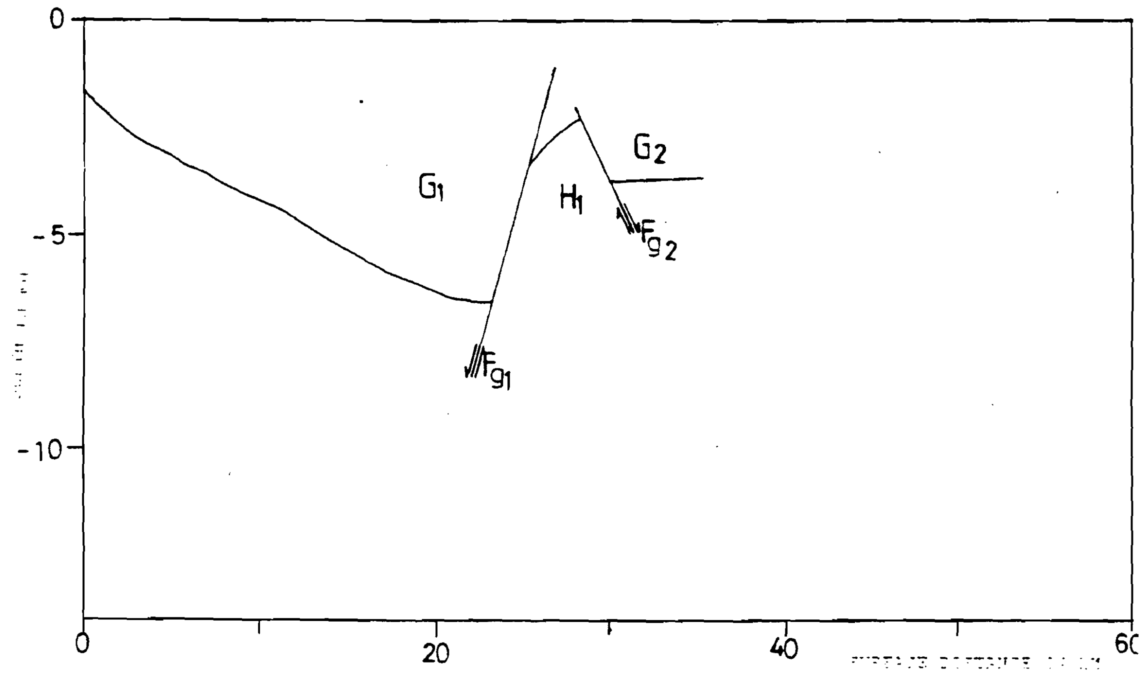

Fig. (12) : Computed Structure Model of Regional Magnetic Profile DD`

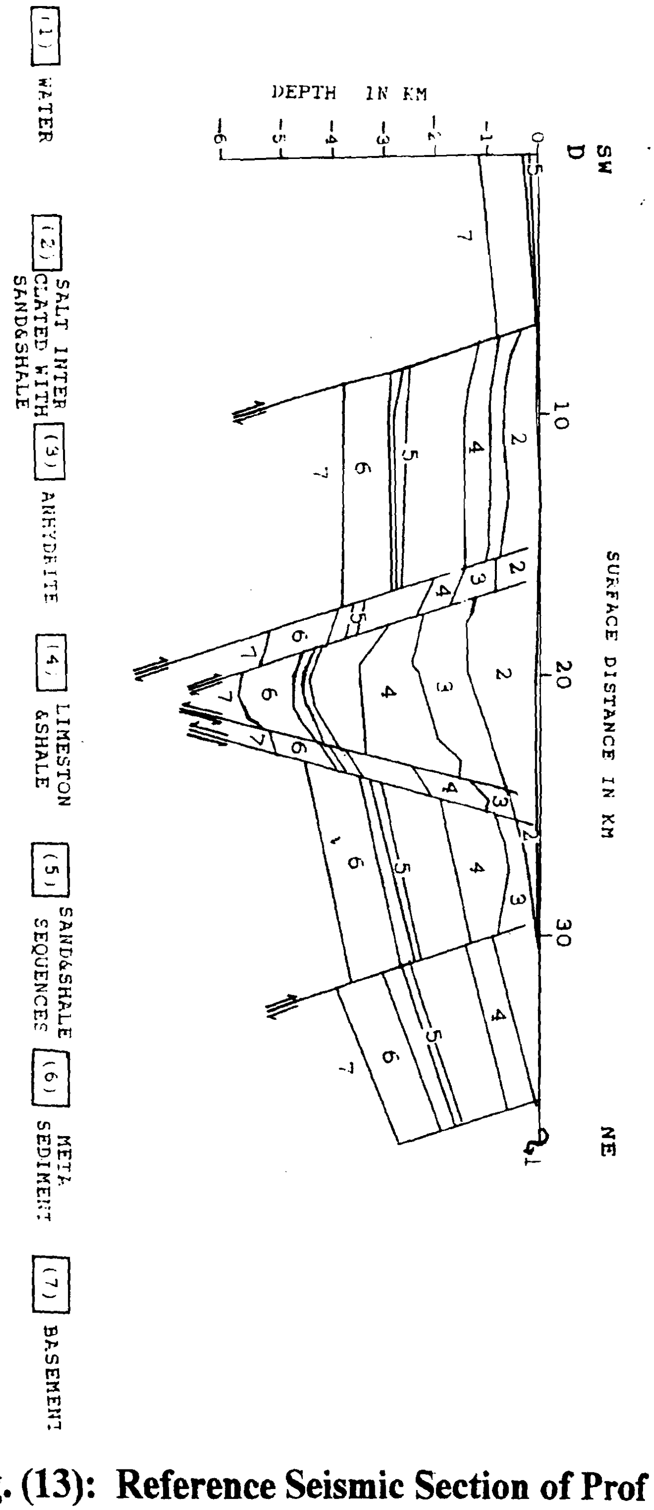

Fig. (13): Reference Seismic Section of Prof DD

- The uplifted structure H_1 in the computed section, is consistent with the seismic section. The magnetic susceptibility contrast of this structure lies in the range $44x10^6$-$1300x10^6$ c.g.s., i.e. it consists of Acidic and Rhyolite intrusive body, probably Granitic shield. The constituents of this uplifted structure indicate that it has a continental crust origin.

- The graben G_1 in the computed section is matched with the corresponding one in the seismic section. The magnetic susceptibility contrast of this graben lies in the range $1280x10^6$-$2774x10^6$ c.g.s., i.e. the area is involved probably by Diabase rocks.

- The uplifted structure H_2, in computed section, is consistent with the corresponding one in the geoseismic section. The magnetic susceptibility contrast of this structure lies in the range $2230x10^6$-$2715x10^6$ c.g.s., i.e. it consists of basaltic intrusive body. It is probably of oceanic crust origin.

From the above mentioned results and from regional magnetic structure model, Fig. (12). we can conclude that the fault F_{m2} in the computed magnetic section and the corresponding fault F_{g1} in the regional magnetic computed section are mostly locating the rifting and new oceanic crust.

- The graben G_2 which lies in the extreme end of the geoseismic section does not appear in the computed magnetic model. But it appears in the computed regional magnetic model.

Profile EE`:

Study of the computed magnetic model of profile EE`, Fig. (14), shows that:

1. The study area is affected by a set of three normal fault, namely; F_{m1}, F_{m2} and F_{m3} (from west to east).

2. Comparison between the computed magnetic model, Fig. (14), and the seismic section, Fig. (16), shows that:

- The uplifted structure H_1, in the computed seis consistent with the corresponding one in seismic section. The magnetic susceptibility contrast of this structure lies in the range $217x10^6$-$670x10^6$ c.g.s., i.e. it consists of Granitic rocks.

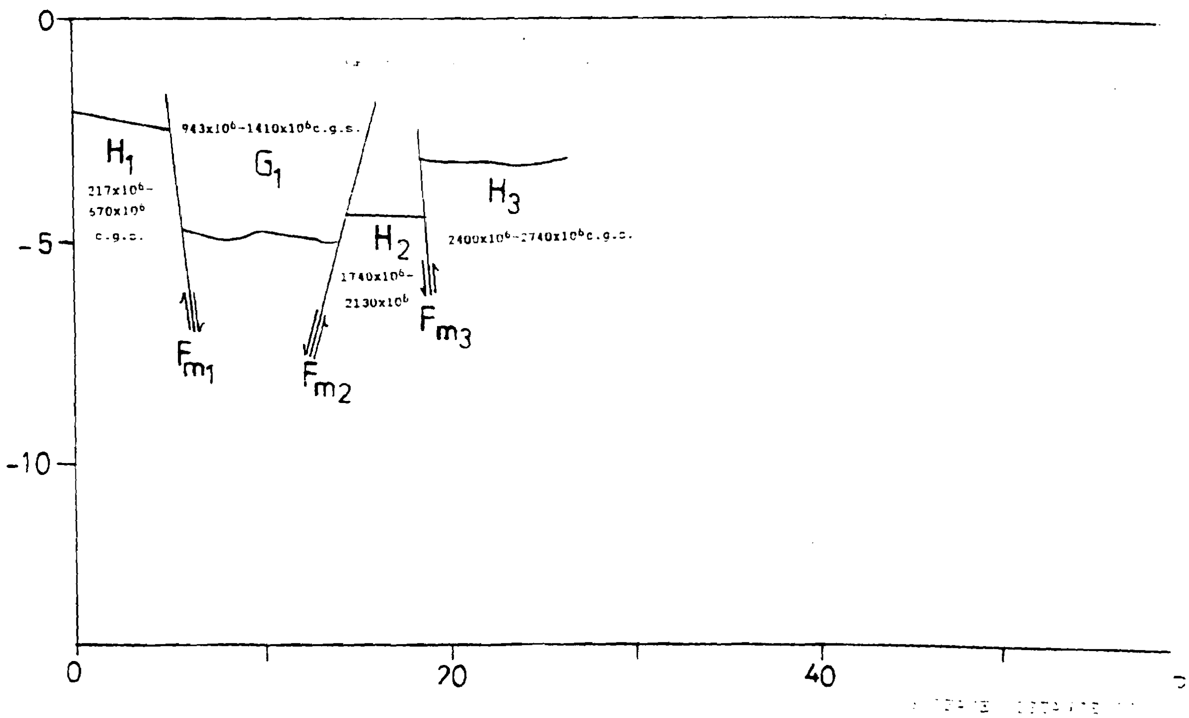

Fig. (14) : Computed Structure Model of Total Magnetic
Profile EE`

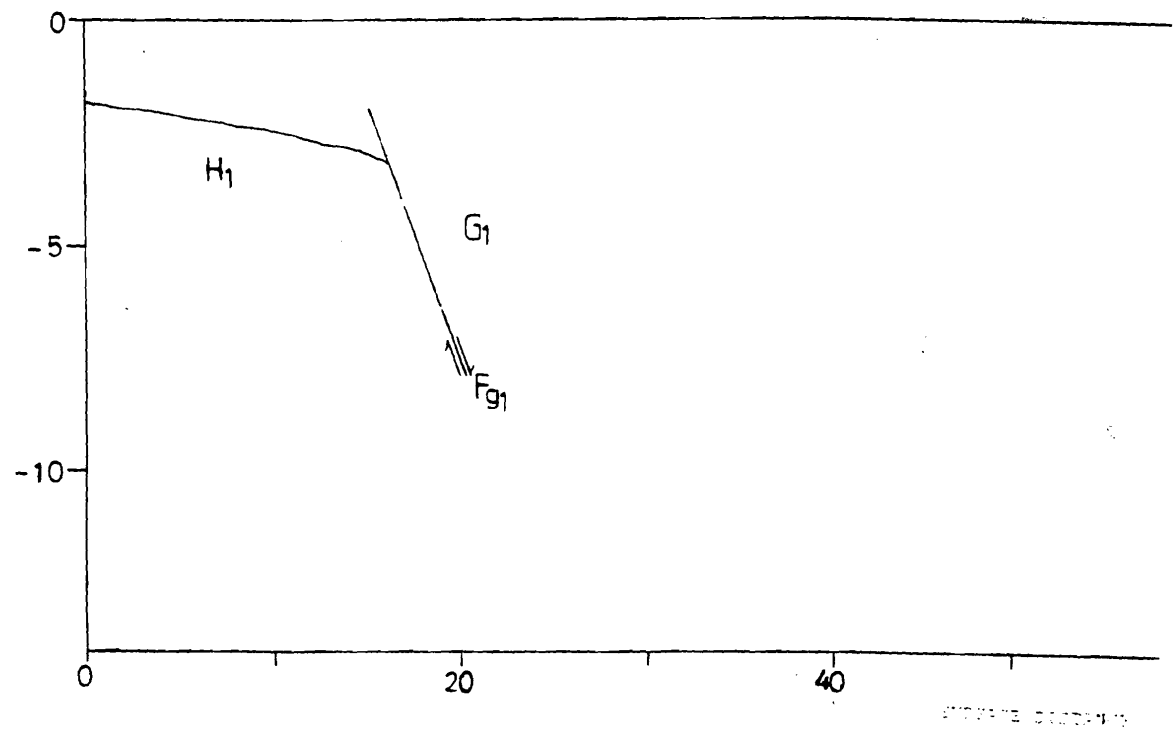

Fig. (15) : Computed Structure Model of Reginoal Magnetic
Profile EE`

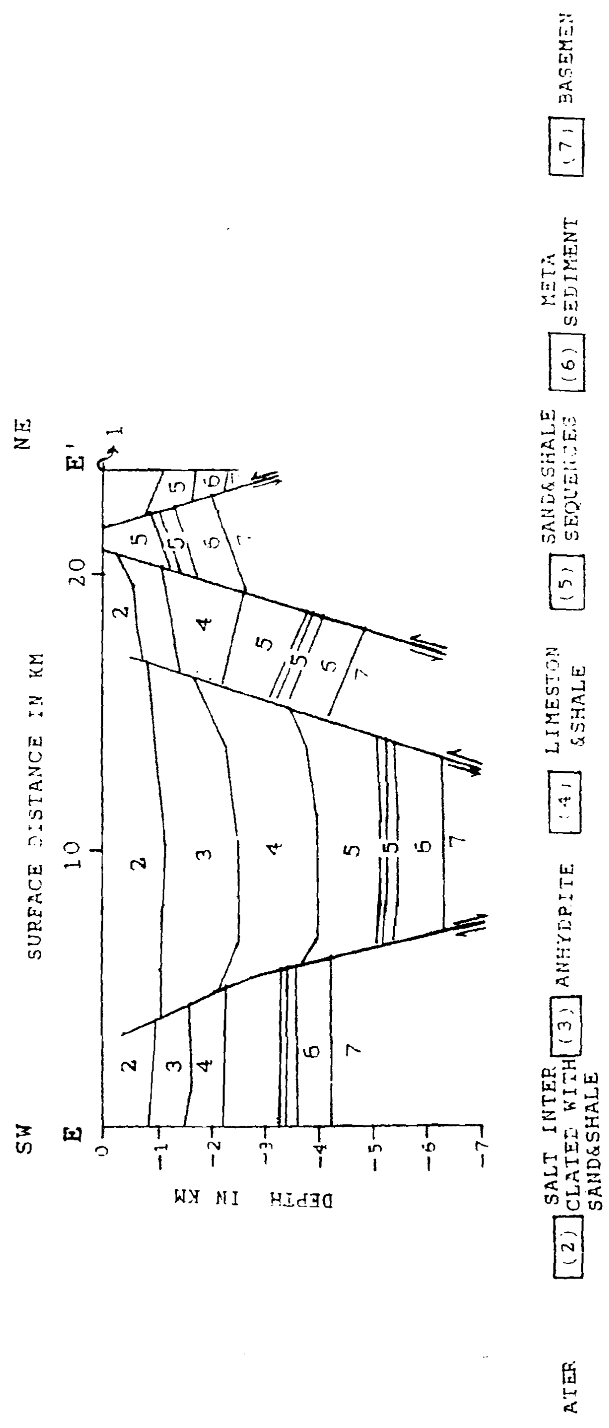

Fig. (16): Reference Seismic Section of Prof EE

- The graben structure G_1, in computed section, is matched with the corresponding one in seismic section. The magnetic susceptibility contrast of it lies in the range $943x10^6$ - $1410x10^6$ c.g.s., i.e. it is probably consists of Gabbro and Rhyolite rock type.

From the above mentioned study, the origin of the area which contains the uplifted structure H_1 and graben structure G_1 lies probably in the continental crust.

- The uplifted structure H_2, in computed section, is consistent with the corresponding one in seismic section. The magnetic susceptibility contrast of this structure lies in the range $1740x10^6$ - $2130x10^6$ c.g.s., i.e. it is constructed by Diabase rocks. It is probably the origin of lateral rifting in the Gulf of Suez.

- The uplifted structure H_3, in computed section, appears in the geoseismic section. The magnetic susceptibility contrast of this structure lies in the range $2400x10^6$-$2740x10^6$ c.g.s., i.e. it is a basaltic intrusive body. The origin of this area is probably of oceanic crust. The profile as a whole affected by suprabasement structure.

CONCLUSION

- The calculated model emphasize the intrusive bodies, suprabasement and intrabasement structures, as well as an assumed mid axis of rifting the Gulf of Suez.

- The sections reveal the existence of birifting process in the middle part of the study area.

- The computed magnetic susceptibility contrast clarify the continental crust, oceanic crust together with a new oceanic crust. Moreover, the ..of magnetic susceptibility shows that the study area has been suffering from an intrusion of Acidic body interfered by different kind of basic rocks, i.e. Granites, Gabbro, and Diabase (which constitute the continental crust), besides the Basaltic intrusive bodies (which constitute oceanic crust).

Conclusively, this technique is applicable and simple to throw light more concisely with better resolution on some detailing of the subseated structure. It is applicable within the framework accuracy of the causative structure when compared with geoseismic sections.

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