QUANTITATIVE INTERPRETATION OF THE MAGNETIC DATA IN WESTERN SINAI PENINSULA, EGYPT

*Mohamed G. El-Malky** and Mohamed H. Abd ELALL**

* Institute of Environmental studies and Research, Ain Shams University, Cairo

** Faculty of Education, Ain Shams University, Cairo

ABSTRACT

The main aims of this study are:

a) To define the hidden structures of the basement surface in the studied area, with emphasis on the recognition of their types (faults or dykes)>

b) To determine the dykes parameters.

To achieve the objectives of this study different quantitative methods were applield on the selected magnetic profiles, where firstly faults and dykes were detected. Through further quantitative analysis of the magnetic profiles (that interpreted as dykes), the dykes parameters, such as width, depth, dip and magnetic susceptibility, have been determined.

INTRODUCTION

The studied area lies on the western side of Sinai Peninsula (See Fig. 1). This area has an interest because of its natural resources, that have been certainly influenced by the basement structures.

There are several methods of the quantitative interpretation, each one having varying degrees of success for a particular application. A fundamental problem in the interpretation of magnetic anomalies is the lack of anyunique in any particular case.
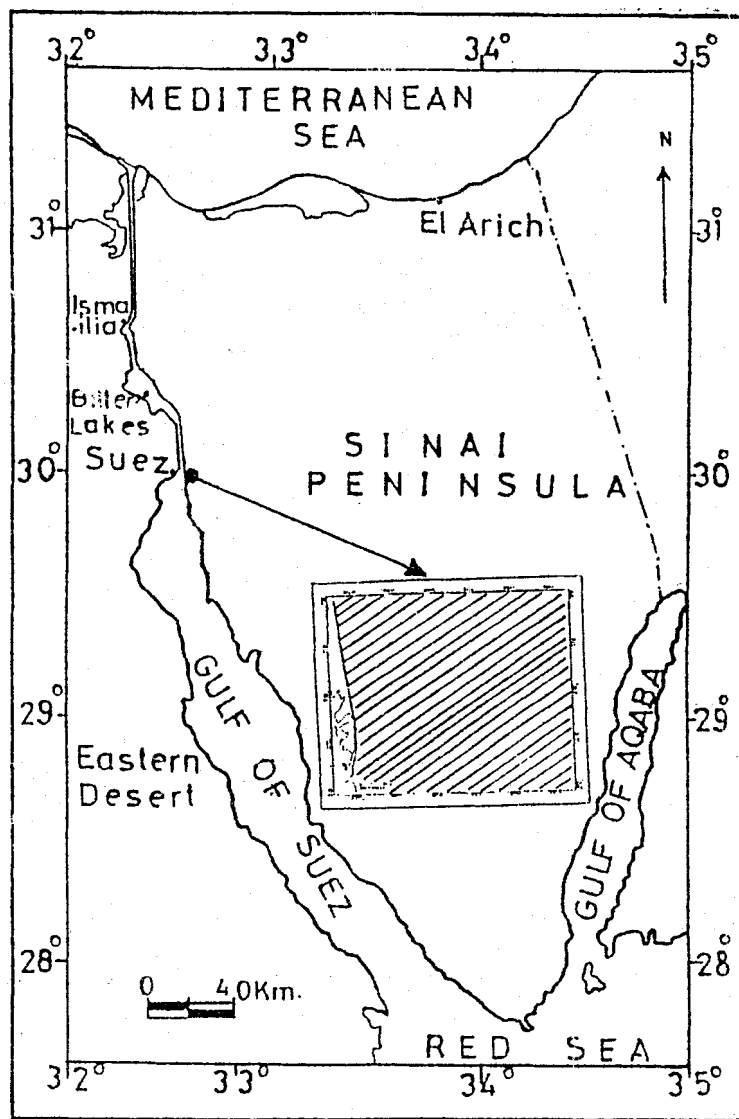
Fig. (1) Location map of the area under study .

The causative body may be described by an infinite number of parameters.

One commonly used method in interpertation is the comparison of standard curves, derived from a model, with measured data and then refined using an iterative process. Much work in this field was done by Gay (1963) who published curves for thin and thick dykes.

A method which is favoured in the field due to its simplicity and quickness is a direct measurement of the profile. There are little more than "rule of thumb" techniques.

Peter's rule (1949) "the horizontal distance between the two points on one side of the profile peak where the slope is half the maximum is approximately 1.6 times the depth to the top of the causative body". There are other rules which are variations of this, which can only be applied under specific conditions.

In this study different methods were applied in the analysis of some magnetic profiles, that have been selected and located on the total intensity magnetic map Fig. 2. These profiles show the strikingly disturbed sites within the studied area as indicated by clear anomalies.

METHODS OF INTERPRETATION

The methods of quantitative interpretation used in this study are: Powell's method, (1), the complex gradient method, (2), koulomzine et al method, (3), and Durantny and krs method, (4). These methods and the results obtained are going to be mentioned in the next few pages.

Fig .(2) Total Intensity Magnetic Map Of The Studied Area, Constructed By M .H . Abd El –All .

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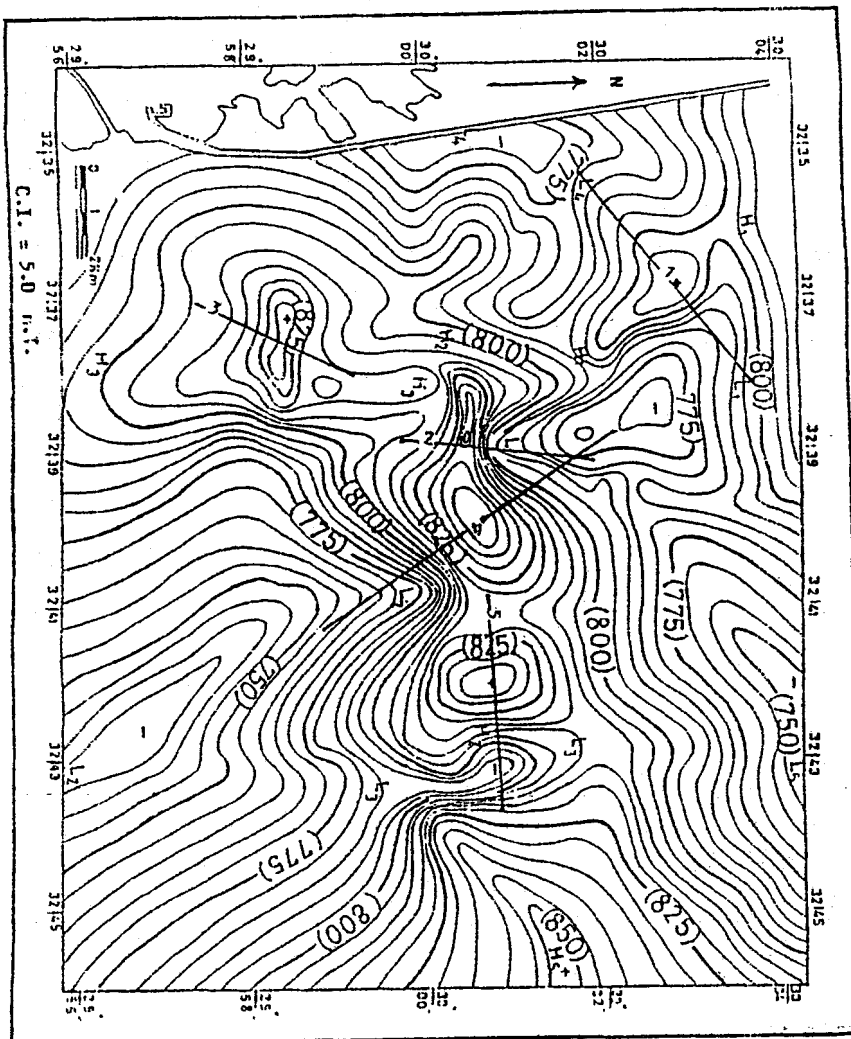
1. Powell's Method :

In this method the observed profiles were adjusted to conform to that symmetry shown by the function describing the magnetic anomaly due to a dyke or vertical fault. By minimising these adjustments the ideal dyke or fault profile closest to the observations is constructed. During the application of this method the authors avoided such anomalies in which odd-function predominates. For further details and the theoretical background see Powell (1966).

Powell's method was applied on the selected profiles No. 2, No. 3 No. 4 and No. 5, where:

a- the distance between the assumed and revised origin has been calculated for each profile.

b- adjustment of the observed profile.

c- resolving each profile into its even and odd components, where even component used for the quantitative interpretation.

d- determination of the dyke or fault geometry.

The results of this method as indicated in Figs. 3,4,5,6, and 7 show that:

I- The anomalies along profiles No. 1, No. 2 and No. 3, as demonstrated in Figs. 3, 4 and 5, reflect vertical faults on the basement surface.
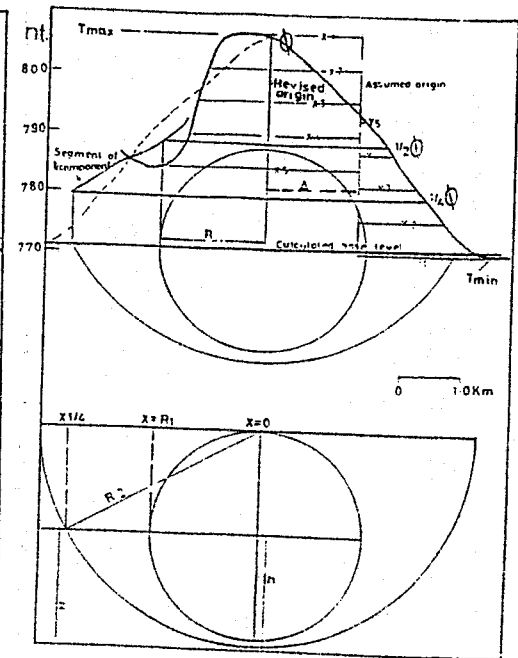
II- The anomlies along profiles No. 4 and No. 5 can be attributed to vertical dykes, as seen in Figs. 6 and 7. The parameters of these dykes are presented in the next table

Quantitative interpretation of the magnetic data in western......
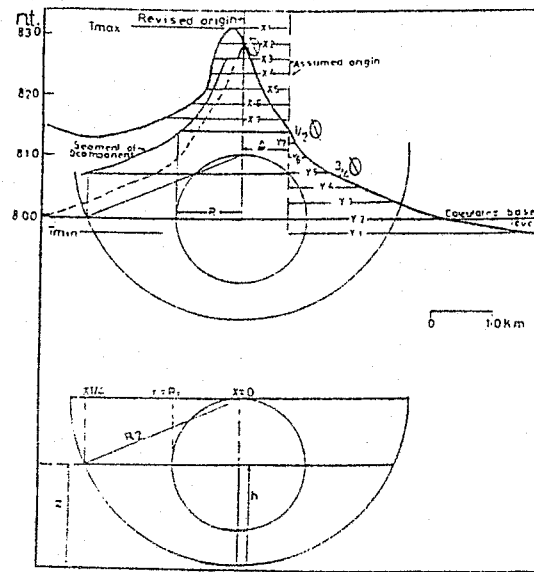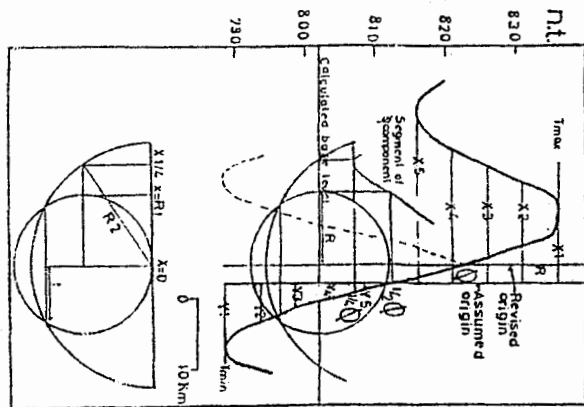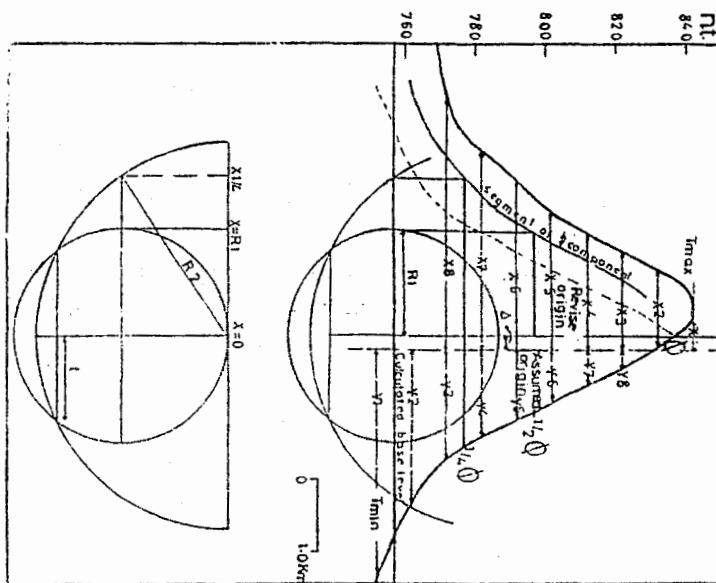

Profile No.3

Fig. (5)
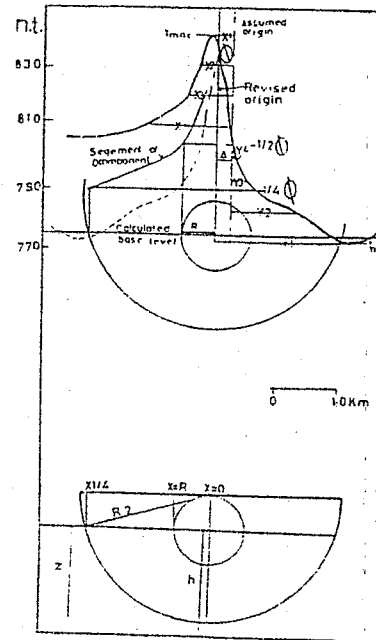
Profile No.2

Fig.(4)

Profile No.1

Fig.(3)

Figs.(3,4,and 5) Show Interpretation Of The Adjusted Profiles,Where Vertical Faults Were Deduced.

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Fig. (7)

Profile No. 5

Fig (6)

Profile No. 4

Figs.(6 and 7) Demonstrate Interpretation Of Dyke Geometry From Even Components

Of The Adjusted Profiles Nos.4 and 5.

Table (1) : The parameters of the dykes, using Powell's method.

Profile No.	Depth to the top of the dyke	Width
4	0.90 km.	2.35 kms.
5	0.65 km.	1.50 kms.

2 The Complex Gradient Method:

Atchuta Rao, Ram Babu and Sanker Narayan (1981) introduced a method to interpret the magnetic anomaly due to a dipping dyke. this method can be summarized as follows:

i   - calculating the horizontal gradient of the observed profile, using either Helbert Transform or simple differentiation.

ii - calculating the vertical gradient using Helbert Transform.

iii- from the results of the previously mentioned steps (No. i and No. ii) the amplitude and phase angle can be determined.

iv - using the following equations, talking in consideration that b > h, :

$$\frac{A_o}{A_M} = \frac{2bh}{b^2 + h^2} \tag{1}$$

and
$$\frac{2 A_B^2}{A_o A_M} = \frac{b}{h} \tag{2}$$

where, h is the depth of burial,

b is the half width of the dyke, and the other symboles are illustrated in Fig. 8b.
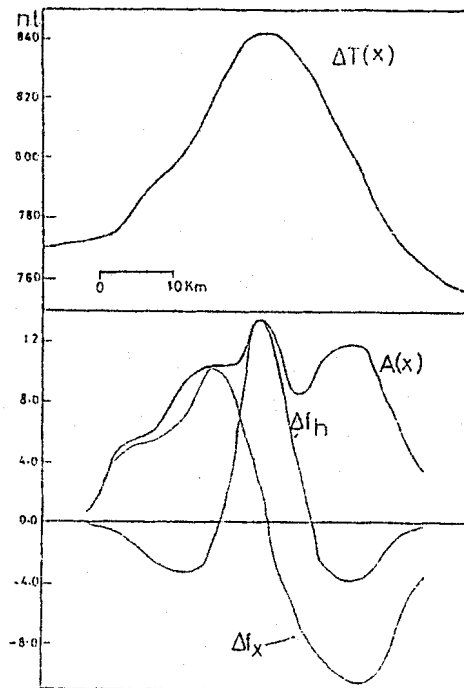
Fig. (8A) The observed profile No . 4 ,$\Delta I(x)$,and its horizontal gradient $(\Delta\Gamma_x)$,
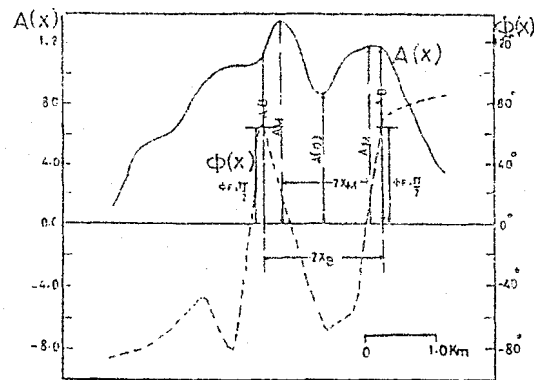vertical gradient($\Delta\Gamma_h$)and amplitude function A(x).

Fig.(8B) The amplitude function A(x) and the phase function $\beta(x)$ of the complex
gradient for quantitative interpretation of a dyke , using profile No.4

For further details see Atchuta Rao, Ram Babu and Sanker Narayan (1981).

This method was applied on profile No.4, where the results are demonstrated on Figs. 8a,, and 8b as well as the following Table.

Table (2) : The parameters of the dyke, using the complex gradient method.

Profile No.	A_M	A_B	A_O	Dip	Width (2b)	Depth (h)
4	127	116	86	67.5	2.55 km	1.04 km.

3. Koulomzine, Lamontagne and Nadeau's method:

Koulomzine *et al* (1970) suggested a method for direct interpretation of magnetic anomalies caused by inclined dykes of infinite length. This method is based, first, on the decomposition of the field curve into its symmetrical and antisymmetrical components with a method that uses arbitrarily chosen conjugated points and, second, on the analysis of these two components separately.

The location of the centres (x=0) of the two magnetic field curves No. 4 and No. 5 which detected on the map (Fig. 2) have been established by the Lamontagne method (1970), as quoted by koulomzine et al (1970) either by calculating u= m.n//L-m+n,

where the symbols of this equation are illustrated in Figs. (9A) and (10A) and graphically by constructing triangle ABC with line BC parallel to line E'_2 E''_2 where (E'_2, E''_2, E'_1 and E''_1) are conjugated points as shown in Figs. (9A) and (10A). Then the separation of the two observed magnetic curves into their components have been carried out as shown in Figs. (9B) and (10B). The depth (h) and width (W) of each dyke are obtained, making use of its symmetrcal components, using following equations:

$$\text{Depth (h)} = 2.X_{1/2} \cdot \frac{(\alpha^2 - 1)}{4\,\alpha} = 2X_{1/2}.D \tag{3}$$

$$\text{Width (W)} = 2.X_{1/2} \cdot \frac{4 - (\alpha^2 - 1)^{1/2}}{2.\,\alpha} = 2X_{1/2}.w \tag{4}$$

where

(α), being a quotient, is scalar and is independ of any measurement units and equal $\dfrac{X_{1/2}}{X_{3/4}}$

1/2 and $X_{3/4}$ are the distances between the points of half and three quarters maximum values of the symmetrical components.

D and w are independent scalar and read off from Master curves corresponding to the α.

Also, these parameters can be obtained using antisymmetrical components and the following equations :

$$\text{Depth (h)} = 2\,Xe\,\frac{(1 - U)^2}{4U} = 2X_e.D \tag{5}$$
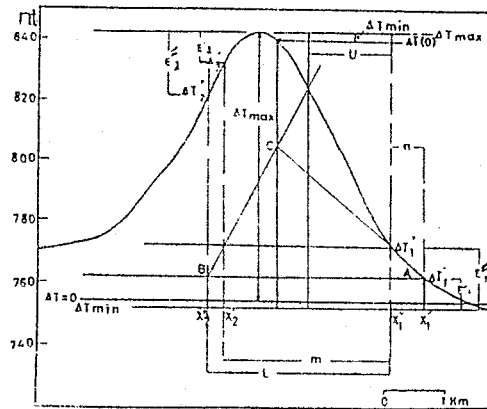
Fig. (9A) Locating the origin of the magnetic profile No. 4, using Lamonatage
method as quoted from Koulomzine et al 1970.

Fig. (9B) The symmetrical and antisymmetrical components (of the magnetic profile No.4)
which are used ,for the quantitative interpretation ,to deduce the geometry
of the dyke.

Fig. (10 A) Locating the origin of the magnetic profile No.5 , using Lamontag method as quated from Koulomzine et al 1970 .
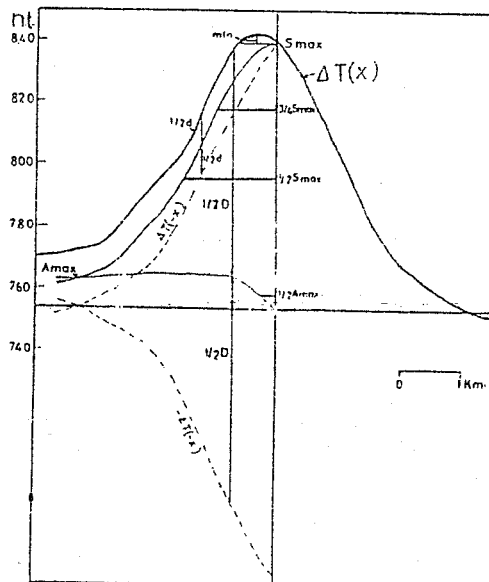

Fig. (10B) The symmetrical and antisymmetrical components (of the magnetic profile No.5) which are used,for the quantitative interpretation ,to deduce the geometry of the dyke.

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$$\text{Width (w)} = 2b = 2\,X_e \frac{4\,U^2 - (1-U)^4}{2\,U}^{1/2} = 2\,x\,e \qquad (6)$$

where

(U) being a quotient, is scalar, is independent of any measurement units, and equal $\dfrac{X_e}{X_e/2}$

Xe and Xe/2 the maximum and half maximum values of the symmetrical components.

D and w are independent scalar and read off from master curves corresponding to the U.

The parameters (depth, width and dip) along profiles No. 4 and No. 5 of the dykes are represented in the next table.

Table (3) : The parameters of the dykes using Koulomzine et al.'s Method.

Profile No.	Average depth (d)	Average width (W)	Dip
4	1.11 km	2.04 km	58.47
5	0.603 kg	1.44 km	59.26

4. Durantny and Krs Method:

Durantny and krs method (1963), referred from Diasty (1969), gives a general case of dyke which is magnetically homogeneous and polarized in any direction. To apply this method, the sysmmetrical curve along profiles No. 4 and No. 5 was computed,

as shown in Figs. (11) and (12) where the maximum magnetic intensity value (Y_{max}) was determined. If Y_2 is the abscissa of the point with value of $Y_2 = 1/4$ Ymax, and Y_1 is the abscissa of the point with value of $Y = 1/2$ Ymax, the depth (h) and width (2b) of this dyke can be computed from following equations:

$$h = \pm \frac{Y_2^2 - Y_1^2}{2Y_1} \tag{7}$$

$$b = \pm (Y_1^2 - h^2)^{1/2} \tag{8}$$

The approximated value of susceptibility contrast between this dyke and the surrouding rocks, without regard to remanent magnetization, could be calculated as follows:

According to the method the anomaly produced by a hemispherical body $= 2\pi Y$

$$\text{Hence} \quad 2\pi Y = \Delta T.\frac{180}{\theta} \tag{9}$$

Where

θ is the space angle of the body and

$$Y = \Delta K\text{-}Z_o, \tag{10}$$

$$2\pi\Delta K\, Z_0 = \Delta\, T.\frac{180}{\theta}$$

Z_o represented, the vertical component of the earth's magnetic field, and according to Ahmed *et al.* (1977), $Z_0 = 30400$ nT in the area under study.
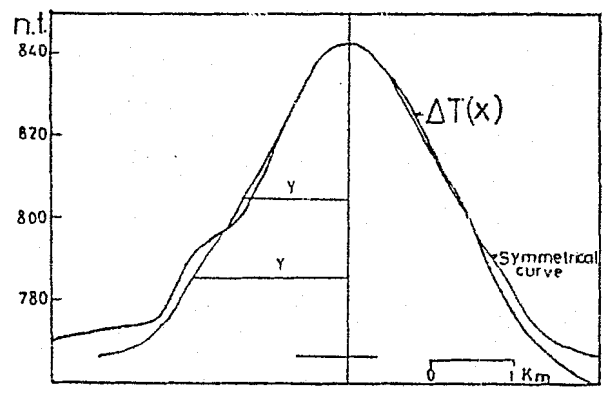
The space angle of the body$= 2\tan^{-1} \frac{b}{h}$

Fig .(11) Analysis Of Profile No. 4 ,Using Durantny and Krs Method
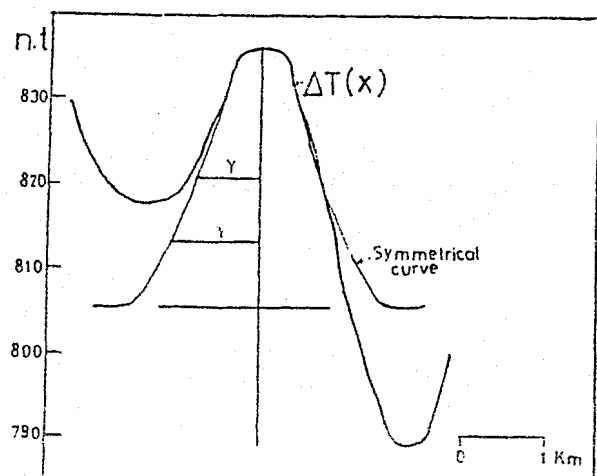

Fig.(12) Analysis of Profile No. 5,Using Durantny and Krs Method.

$$\text{then } \Delta K = \frac{\Delta T. \frac{180}{\theta}}{2\pi \, Z_o} = \frac{\Delta T. \, 180}{2\pi. \, Z_o.2 \tan^{-1} b/h} \qquad (11)$$

According to this method the parameters of the dykes along profiles No. 4 and No. 5 are represented in the following table

Table (4) : The parameters of the dykes Using Durantny and Krs's Method

Profile No.	h	b	o	k	Inferred Rock Type
4	0.73	1.07	111.39	0.00318	Rhylotic
5	0.055	0.5	84.54	0.0016	Granitic

CONCLUSION

In this study some methods of magnetic interpretation have been applied, firstly to recognize the conceald structures of the basement surface (in terms of dykes and vertical faults) and secondly to evaluate the parameters of the dykes along profiles No. 4 and No. 5 as lislted in the following tables:

Table (5) : Types of the detected structure (based on Powell's method)

Profile No.	Type of the structure
1	Vertical Fault
2	Vertical Fault
3	Vertical Fault
4	Vertical dyke
5	Vertical Fault

Table (6) : Dykes parameters

Profile No.	Parameter	Powell's Method	Complex Gradient	Koulomzine et al Method	Average
4	Depth	0.90 km	1.04 km	1.11 km	1.01 km
	Width	2.35 km	2.55 km	2.04 km	2.313 km
Dyke (1)	Dip	–	67.5°	58.47°	62.98
5	Depth	0.65 km	–	0.603 km	0.626 km
	Width	1.5 km	–	1.44 km	1.47 km
dyke (2)	Dip	–	–	59.26	59.26°

The application of Durantny's and Krs method, on profiles No. 4 and No. 5, shows magnetic susceptibility of 0.00318 and 0.0016 for the first and second dykes respectively. These values characterize rhylotic and granitic rock types.

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فسير كمى للبيانات المغناطيسية غرب شبه جزيرة سيناء-مصر

محمد غريب المالكى   ،   محمد حامد عبدالعال

ان الاهداف الاساسية من هذة الدراسة هى:

تحديد التراكيب التحتسطحية الموجودة بسطح الصخور القاعية فى منطقة الدراسة مع التأكيد على التعرف عليها من حيث كونها صدوع أوجدد قاطعة ولتحقيق أهداف هذه الدراسة تم تطبيق طرق تفسير كمية ومختلفة على منحنيات مغناطيسية منظورة ومختاره ، حيث أمكن التعرف أولا على الصدوع والجدد القاطعة.

ومن خلال التحليل الكمى لمنحنيات الجدد القاطعة أمكن تعيين معلمات هذه الجدد القاطعة مثل العمق-الاتساع-الميل والحساسية المغناطيسية