A Rapid Graphical Solution for Determining the Presence of Remnant Magnetization in the Basement Rocks of Western Iraq

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ABSTRACT

A graphical method of determining the possible presence of a remanent component of magnetization in two dimensional igneous masses within the basement is described. It is required to assume that the same source produces well defined gravity and magnetic anomalies. The method involves taking the ratios of distance between peaks of maximum values of gravity and magnetic for various angles of field inclinations. Ratio of maximum positive and maximum negative values for various angles of field inclinations are also used. These ratios are plotted against field inclinations. Examples of anomalies are taken from the western desert area of the stable shelf in Iraq.

مخططات حلول سريعة للتعرف على وجود المغناطيسية المتبقية في صخور القاعدة في الجزء الغربي من العراق

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الملخص

يهدف البحث إلى إيجاد مخططات قياسية لمعرفة مدى إمكانية وجود المغناطيسية المتبقية في الأجسام النارية لصخور القاعدة بالاعتماد على قياس الشذوذ المغناطيسي والجذبي للجسم الناري المسبب لتلك الشواذ. حيث تم إعداد المخططات القياسية بأخذ نسب المسافات بين القيم العليا للشواذ الجذبية والمغناطيسية عند مختلف زوايا الميل المغناطيسي وكذلك النسبة بين القيم الموجبة العليا والقيم السالبة العليا للشواذ المغناطيسية عند مختلف زوايا الميل المغناطيسي. ألنسب المذكورة أعلاه رسمت مع زوايا الميل المغناطيسي.طبقت هذه الدراسة في الصحراء الغربية الواقعة ضمن الجرف المستقر في العراق.

INTRODUCTION

In analyzing the aeromagnetic maps of Iraq, it is usually assumed that the observed anomalies are caused by homogeneously magnetized bodies forming the basement configuration that is concealed beneath a thick cover of sediments.

Many unknowns are faced with in interpreting magnetic anomalies related to deep sources. Among these, direction of magnetization in these sources is most important unknown, with gravity, on the other hand, the maximum values lies directly over the center of gravity of the source. As such, a vertical line passing through the maximum (or minimum) gravity anomaly can be reference line for the location of maximum (or minimum) magnetic anomalies.

Previous studies related to interpretation of aeromagnetic anomalies in Iraq , have assumed that the basement magnetic sources have no remanence and it's magnetization is made only by induction from the present earth's magnetic field(Aziz, 1986; Baban, 1983; Mahmood, 1981). Many authors such as(Ates and Keary, 1995) have discussed the magnetization direction but have restricted the discussion to pseudo-gravity anomaly.

In this paper, it will be considered that the induced magnetization of the source from the present field will be affected if there is remanence in whatever direction within the source. In this case the remanence will have some component parallel to the present field magnetization and hence altering it. The following method is designed to estimate the amount of change in the inclination of the resultant magnetization field.

The Method

Magnetic anomalies are calculated over a line running perpendicular to the strike of an hypothetical two dimensional source using different inclinations of the magnetizing field (Heirtzler, *et al.*, 1962). the gravity anomaly along the same line over the same source is also calculated (Talwani, *et al.*, 1959). These anomalies are shown in fig.(1).

It can be seen that the peak of the gravity anomaly coincides with the positive peak of the magnetic anomaly at magnetization field inclination of 90^{o}, and the two shift apart at different horizontal distances at different field inclinations .

At each field inclination, the distance between the maximum positive magnetic anomaly and the maximum positive gravity anomaly **(D^{+})** is measured. Also measured for each field inclination is the distance between the maximum negative magnetic anomaly and maximum positive gravity anomaly **(D^{-})**. Then for each field inclination the ratio **$R1=D^{+}/D^{-}$** is calculated. A theoretical curve of **R1** against field inclination is constructed (Fig.2) and shows exponential increase of **R1** as field inclination decrease .

With actual gravity and magnetic surveys, **R1** can be measured from the observed anomalies and the field inclination corresponding to it can be read from the curve of Fig. 2. Any variation in the inclination thus measured from the actual field from the area of survey will indicate the presence of a remanent component.

Another ratio **(R2)** which is the ratio between the maximum positive amplitude of the magnetic anomaly to it's maximum negative amplitude from the curves of Fig.1 can be measured at each inclination angle. If **R2** is plotted against magnetic field inclinations the results will show the exponential relations of Fig. 3.

The ratios of R2 (+ve max/-ve max) as shown in Fig. (3) are more accurate and precise by using the equation of Heirtzler for two dimensional igneous body, while the ratios R2 or (Ar)(+ve max/-ve max) as mentiond by Sharma (2004) for calculating the inclination angles which represent an approximate values as in Table (1).

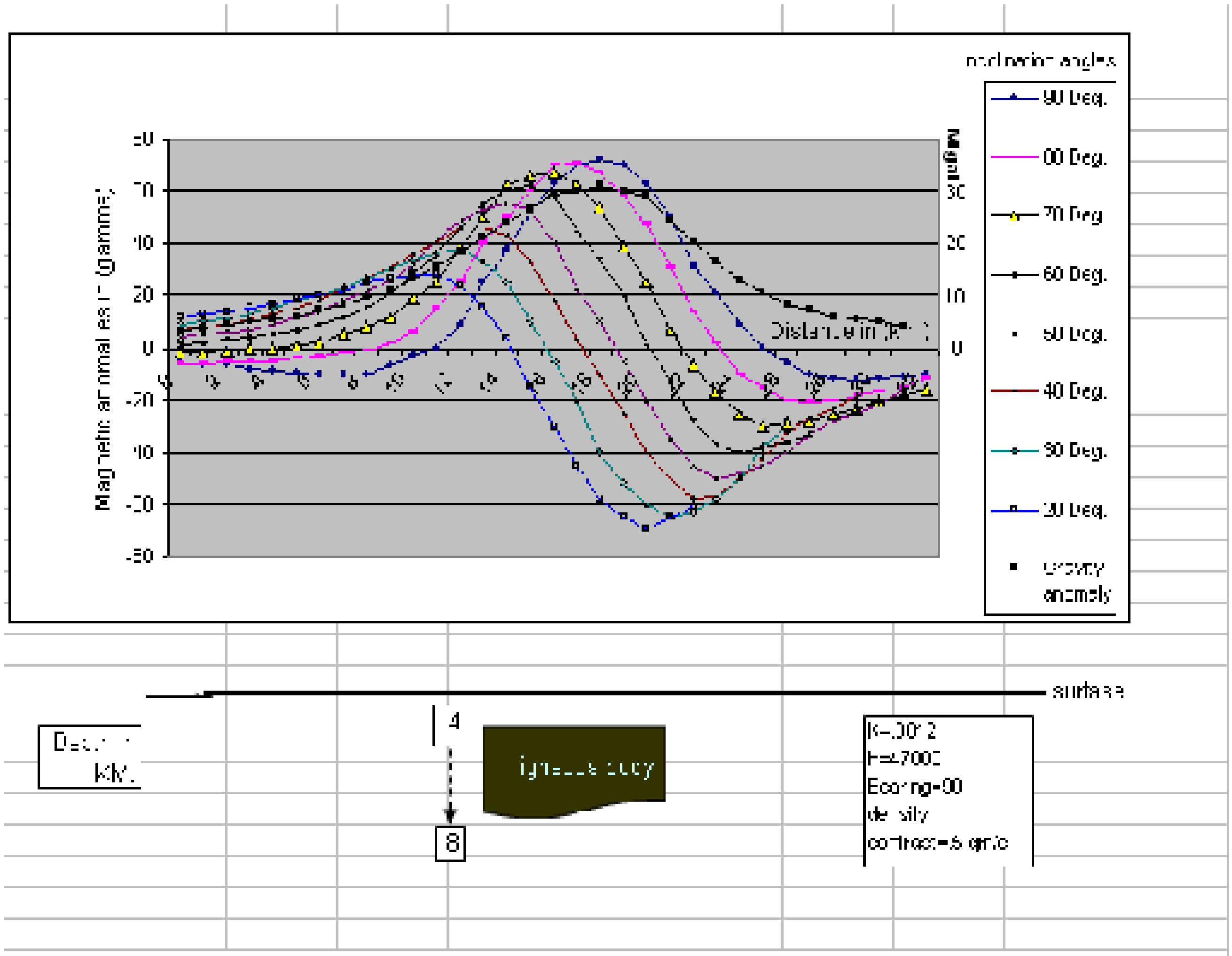

Fig. 1: Theoritical calculation for gravity and magnetic anomalies at different inclination angles for two dimensional igneous body

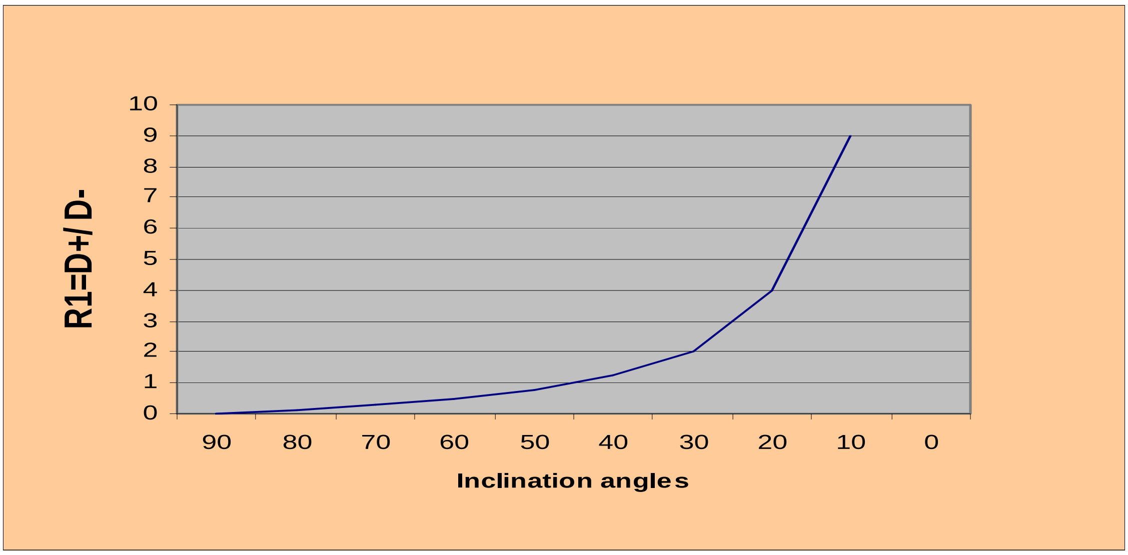

Fig. 2: Standard curve showing the relationship between the ratio **(R1)** and inclination angles.

Table 1: Variation of R2 values with magnetic inclination angles

Using Heirtzler equation		Sharma	
Inclination	R2(+ve max/-ve max)	Inclination	*(R2 or) Ar (+ve max/-ve max)
20	0.4	0-20	1
30	0.6	30-50	2-----5
40	0.77	60-75	6-----20
50	1.1	------	-------
60	1.55	------	-------
70	2.1	------	------
80	3.3	------	------
90	5.8	------	------

* R2=Ar , As presented from the research.

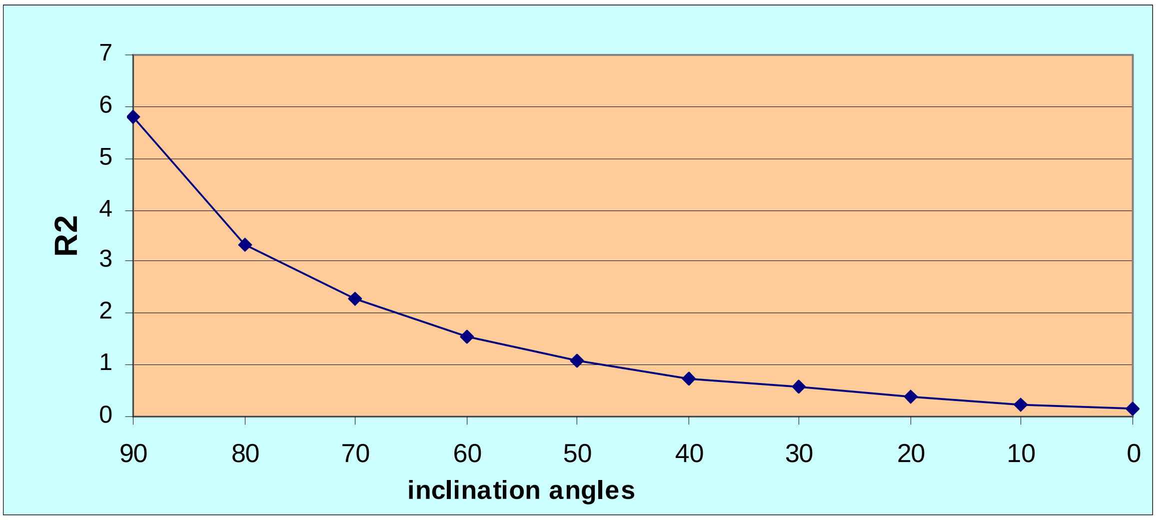

Fig. 3: Standard curve showing the relationship between ratio(**R2**) and inclination angles.

Obviously, the maximum positive and maximum negative amplitude will depend on position of the zero line of the anomaly and this, in most cases, can not be uniquely determined.

The Application

In order to illustrate the method described above an example of prominent magnetic and gravity anomalies have been chosen from the western desert of the stable shelf south of the Euphrates river in Iraq.

GADA HIGH GRAVITY AND MAGNETIC ANOMALIES

The gravity map shown in Fig (4) represents the gravity effect of the basement topography after removal the effect of sedimentary cover from the observed Bouger anomaly by stripping method. (AL-Najar, 1999). The map shows a circular positive anomaly represented by GADA high, with a maximum and minimum gravity contour values of +3 mgal and 0 mgal respectively.

Gravity profile is taken along the line **G**sw-**G**NE which trends SW-NE as shown in Fig(4) and Fig(6).

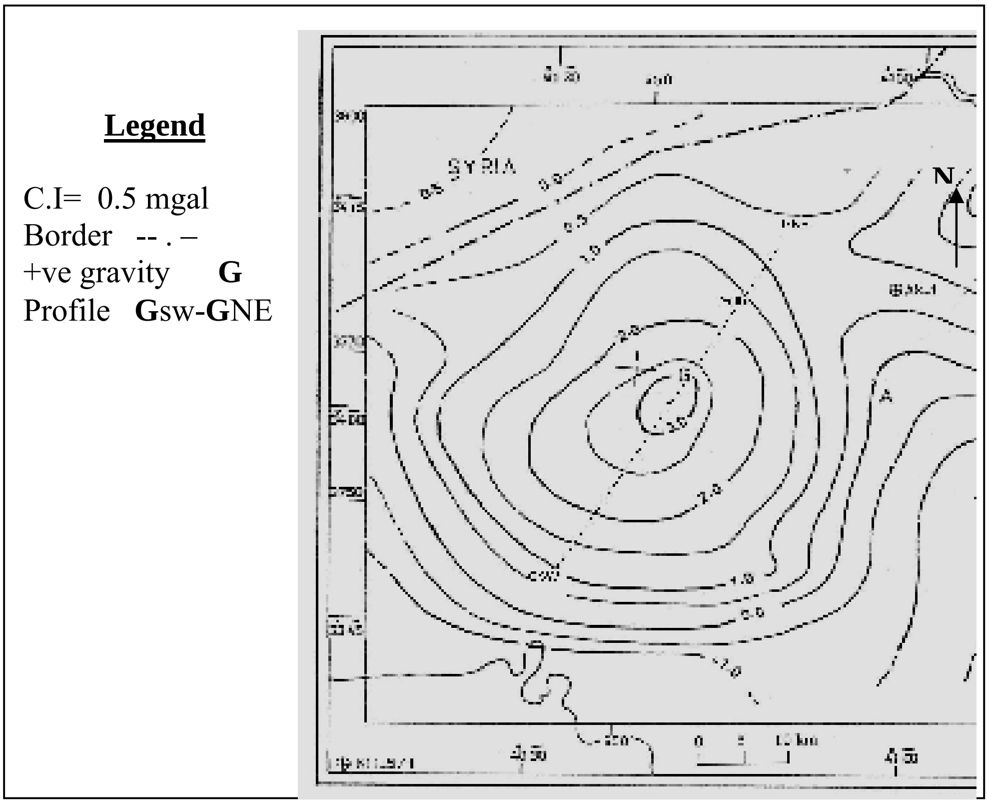

Fig. 4: Gravity effect of the basement topography (after Al-Najar, 1999).

The aeromagnetic map for the same area as shown in Fig(5), where the magnetic inclination angle is about 50 degree shows a large +ve magnetic anomaly (**G**+) at a value of 5075 γ with east-west elongation and –ve magnetic anomaly (**G-**) at about 4945γ at the north east. The magnetic anomaly is associated with the gravity GADA high in fig(4), and these two anomalies are related to the same source (GADA igneous body), (Al-Najar, 1999). Magnetic profile is taken along the line **G**sw-**G**NE which trends Sw-NE as shown in Fig (5) and Fig (6).

The peaks of both anomalies (gravity and magnetic anomalies) seen in Fig (6) are related to the same source. The measured distance between the two +ve. peaks of gravity and magnetic profiles (D^+) is about 9.5 Km. While the measured distance between the +ve. Peak of gravity anomaly and –ve. Peak of magnetic anomaly (D^-) is 22.5 Km., thus the ratio R1= 0.42 equivalent to inclination angle 63 degree (by using the graph in Fig.(2)). In another way the ratio of +ve. To –ve. Magnetic anomalies fig.(6) is 75/51= 1.47 that is equivalent to inclination angle 60 degree (by using the graph in Fig.(3)).

The two values of inclination angles in the two cases are very similar, but this small difference is related to how to choose the zero line.

It would appear, therefore, that the calculated values of inclination angle is more than the true inclination angle in the area at about 10-13 degree. It should, therefore, be emphasized that anomalies in the magnetic field of the region are related not only to induced magnetization, but also to the remanent magnetization in the igneous rocks.

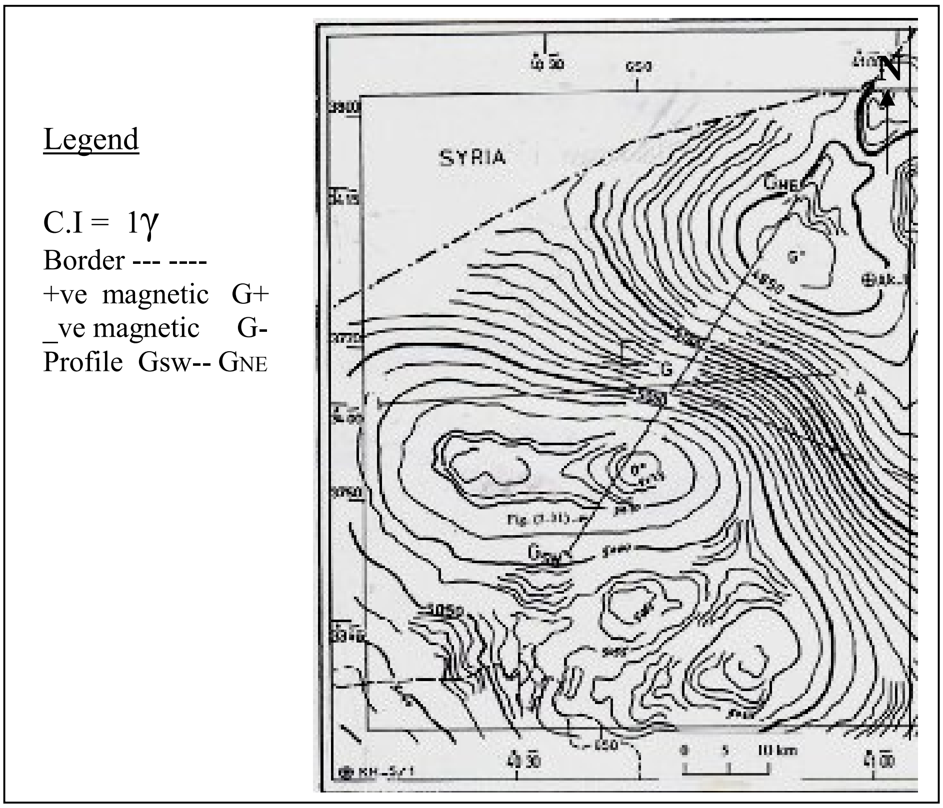

Fig. 5: Total intensity aeromagnetic map (after C.G.G., 1974).

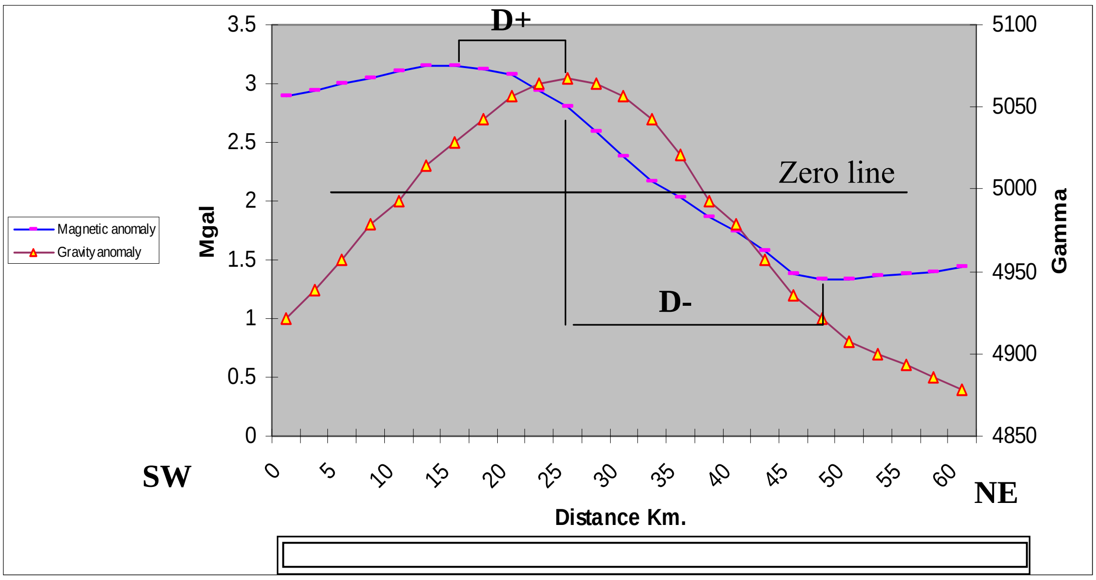

Fig . 6: Gravity and magnetic anomalies of the same source.(after Al-Najar, 1999).

RISHAGRAVITY AND MAGNETIC ANOMALIES

The gravity map shown in Fig (7) represents the gravity effect of the basement topography after removal the effect of sedimentary cover from the observed Bouger anomaly by stripping method. (AL-Mufarjy, 2000), the map shows a positive anomaly represented by RISHA high with a maximum and minimum gravity contour values of -31 mgal and -36 mgal respectively, with north west – south east elongation.

Gravity profile is taken along the line A—A1 which trends north east – south west 45 degree (Mutib, personal communication) as shown in Fig(7) and Fig(9).

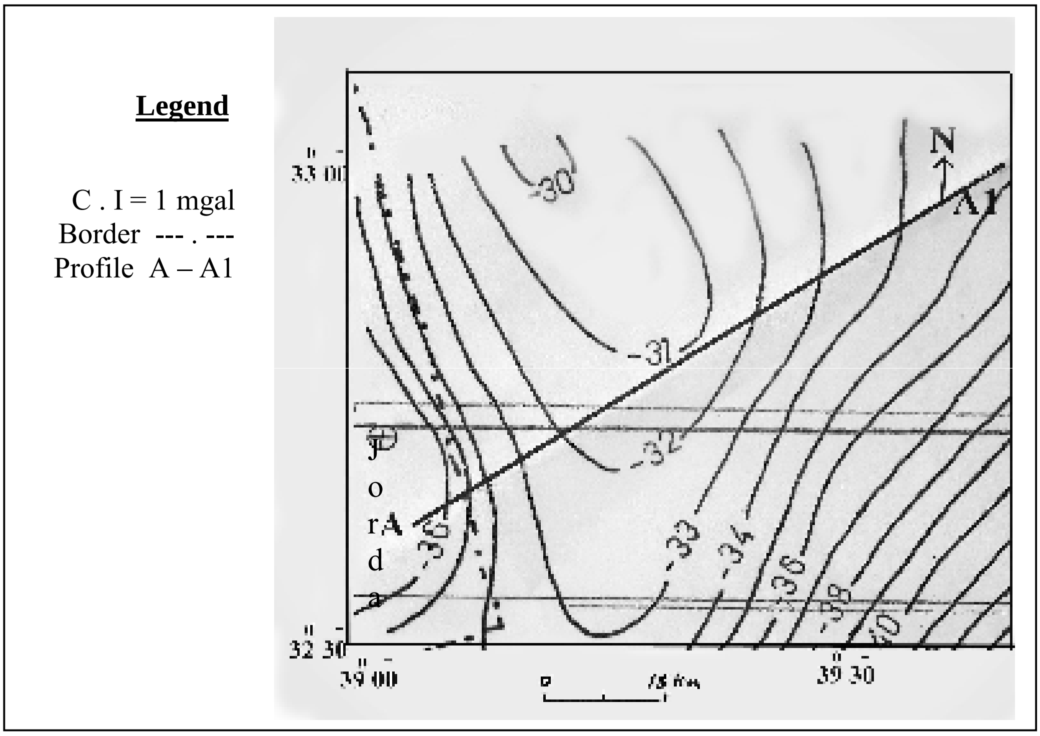

Fig 7: Gravity effect of the basement topography after removal of the sedimentary cover (after AL-Mufarjy, 2000).

The aeromagnetic map for the same area as shown in Fig(8),where the magnetic inclination angle is about 50 degree shows a large +ve magnetic anomaly (R+) at a value of 5110 γ with NW- SE elongation and –ve magnetic anomaly (R-) at about 5040 γ at the north east. The magnetic anomaly is associated with the gravity height in Fig(7), and these two anomalies are related to the same source (RISHA igneous body), (Al-Mufarjy, 2000).

Magnetic profile is taken along the line A –A1 which trends north east- south west as shown in Fig(7) and Fig(9).

The peaks of both anomalies (gravity and magnetic anomalies) seen in Fig(9) are related to the same source.

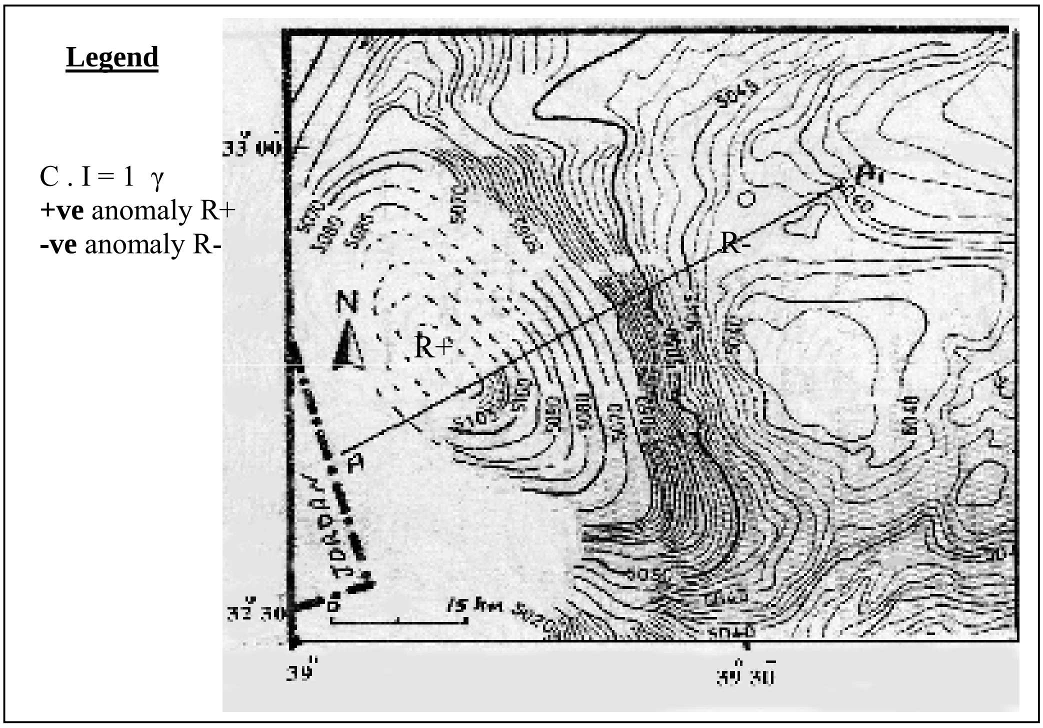

Fig. 8: Total intensity aeromagnetic map (after C.G.G., 1974).

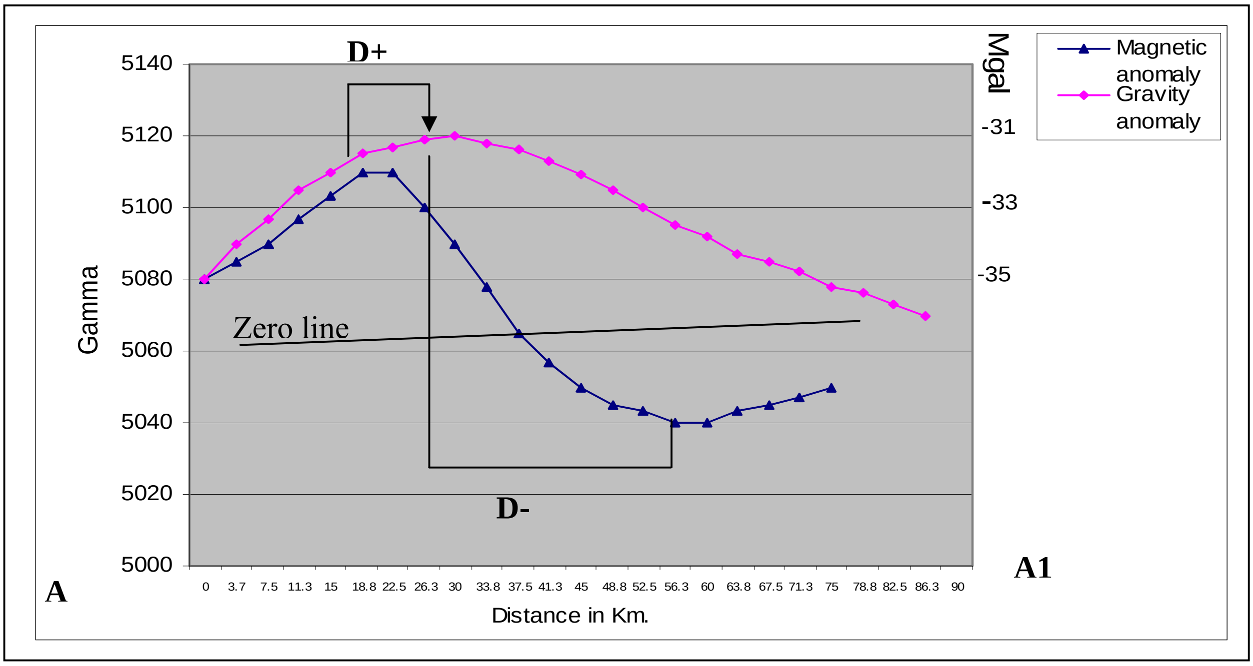

Fig. 9: Gravitational and magnetic anomaly profiles along the line A – A1.

The measured distance between the two +ve. peaks of gravity and magnetic profiles (D^+) is about 9 Km. While the measured distance between the +ve. Peak of gravity anomaly and –ve. Peak of magnetic anomaly (D^-) is 28.5 Km., thus the ratio R1= 0.31 equivalent to inclination angle 67 degree (by using the graph in Fig.(2)).

In another way the ratio of +ve. To –ve. Magnetic anomalies fig.(6) is 45/25= 1.8 that is equivalent to inclination angle 65 degree (by using the graph in Fig.(3)) .

The two values of inclination angles in the two cases are very similar ,but this small difference is related to how to choose the zero line.

It would appear, therefore, that the calculated values of inclination angle is more than the true inclination angle in the area at about 15-17 degree. It should, therefore, be emphasized that anomalies in the magnetic field of the region are related not only to induced magnetization ,but also to the remanent magnetization in the igneous rocks.

CONCLUSIONS

The two examples from the western part of Iraq reflect the magnetization of the basement rocks is made not only by induction from the present earths magnetic field but also presences a component of remanent magnetization that change the degree of the magnetic field inclination in the area.

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REFERENCES

Al –Mufarjy M. A., 2000. Deep Geological Structure for the Southern Part of the Western Desert Using Geophysical Analyses. Ph. D. Thesis, University of Mosul. npublised.

Al- Najar, I.M., 1999. Geophysical Evidence for the Mesozoic and Paleozoic Sedimentary Basins in the Northern Part of the Western Desert. Ph. D. Thesis, University of Mosul, Unpublished.

Ates, A. and Kearey, P., 1995, A New Method for Determining Magnetization Direction from Gravity and Magnetic Anomalies. Jour. of Geophysical Society, Vol. 152, No.3, pp. 561-566.

Aziz, B.K., 1986, Study of Thickness Distribution of the Paleozoic Sediments and Basement Depths in Parts of the Western Desert Based on Seismic Reflection Data. M. Sc. Thesis, University of Mosul, Unpublished.

Baban, E.N., 1983. Analysis of Geophysical Data Available on Abu Rassain Area. M. Sc. Thesis, University of Mosul, Unpublished.

Compagnie General De-Geophisque (C.G.G.), (1974). Aeromagnetic and Aerospectro Metric Survey. GEOSURV. Lib., Unpublished. Report.

Heirtzler, J.R., Peter, G.; Talwani and Zurflueh, E.G., 1962. Magnetic Anomalies Caused by Two-Dimensional Structure: Their Computation by Digital Computers and Their Interpretation. Technical Report No. 6.

Mahmood, S.A., 1981, Interpretation of the Gravity and Magnetic Data of Shbicha Area, Western Desert. M. Sc. Thesis, University of Mosul, Unpublised.

Sharma, P.V., 2004. Environmental and Engineering Geophysics, Cambridge University press.

Talwani, M., Worzel, J.L., and Landisman, M., 1959. Rapid Computation for Two Dimensional Bodies with Application to the Medocine Submarine Fracture Zone .Jour. of Geophysical Res.,Vol. 64, No.1-6, 49 p.