ISOLATION OF RESIDUALS USING TREND SURFACE ANALYSIS TO MAGNETIC DATA

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Abstract

Polynomial surfaces of various degrees are fitted to a magnetic data of Awo area, southwestern Nigeria with the aim of isolating the residuals of the area associated with mineralogy. The fourth degree surface correlates better with the magnetic map of the study area. The residualized data were obtained by subtracting the regional values from the relative magnetic (observed) intensity values. With the application of trend surface analysis to the total magnetic field, the presence of tantalite and associate minerals in the area was established. This shows the applicability of the above technique as a good tool in magnetic data interpretation.

Keywords: *Isolation, trend surface, polynomial fitting, residuals.*

Introduction

One of the greatest tasks in inverse potential problem especially magnetic anomaly interpretation is the separation of regional background anomaly or trend from the data set. There are ways of solving the problem: analytical and empirical. The empirical technique which although is highly flexible employs the traditional method. This is best done by running a smooth line along the suspected trend. This method is also associated with other problems like removing the regional field or trend where the residual is strong. In the present study. the problem was approached analytically. The least squares technique of regional-residual separation was used. In this method, a mathematical surface is fitted to the magnetic data by process of least- squares. The fitting of polynomials to the observed magnetic is used to compute the mathematical surface giving the closest fit to the data that can be obtained within a specified degree of details. This surface is considered to approximate the effect of deep seated or regional structures if it is low degree (Likkason, 1993). The function that generates this surface is called the trend for that specified degree and the consequent analysis of this constitutes the trend surface analysis. The analytical methods and in particular this technique assumes the residuals to be random errors whose sum is zero (Telford et al, 1990). The fitting surface which represents the regional, is a surface which will have both positive and negative deflections from the observed data points with the residuals balanced between positive and negative areas (Nettleton, 1973).

The rather involved mathematical procedure of surface fitting has become feasible with the advent of high capacity electronic computers. Higher degree fits emphasize smaller and sharper residuals in details than low degree fits (Nettleton. 1973). The residual anomalies from surface fitting techniques cannot generally be said to represent the local geological effects for any degree of surface. Therefore not all results from surface fits can be used directly for quantitative geological interpretation by calculating magnetic effects to compare with the observed anomaly. The system is however very effective in picking out local anomalies (Nettleton, 1973). By appropriate choice of the order of residuals it is possible to isolate or emphasize anomalies of almost any magnitude desired within limits of the definition by the spacing of the original data.

Concept of Polynomial Fit

The aim of most surface trend analyses is to obtain a polynomial of sufficiently high order to give a surface of 'best-fit' to the map data. The analyses are done by fitting a trend function described by equations to a set of data. Simpson,(1954) showed that for surfaces of degree n, the trend function F is given by:

$$F(x,y)=\sum_{i=0}^{n}\sum_{j=0}^{n-1}a_{ij}X^{i}y^{j} \qquad (1)$$

where a_i are coefficients to be determined by adjustment using the least-squares method: x,y are co-ordinates of a point at which the function is evaluated. Thus if M(x,y) is the observed magnetic value at the point, then the residual anomaly . R(x,y) will be

$$R(x,y)=M(x,y)-\sum_{i=0}^{n}\sum_{j=0}^{n-1}a_{ij}x^{i}y^{j} \qquad (2)$$

R in the above expression stands for random components and some fluctuations that are being sorted for. A problem of fitting trends involves selection of the terms that are to be included in the trend, after which all remaining terms combined in the residual (Likkason, 1993). It can be seen from equation (2) that once the coefficients a_{ij} are known, the regional values and hence the residual or deviation values will be completely evaluated. The least-squares condition to be satisfied by equation(2) becomes that of determining the position of the surface so that the sum of the squared deviations R is minimum.

Hence,

$$\sum_{k}R^{2}(x,y)=\sum_{k}\left[M(x,y)-\sum_{i=0}^{n}\sum_{j=0}^{n-1}a_{ij}x^{i}y^{j}\right]^{2} \qquad (3)$$

is a minimum, where k is the pattern of observation.

Hence if,

$$(a_{ij}'s)=\sum_{k}R^{2}(x,y) \qquad (4)$$

Then

$$I(a_{ij}'s)=\sum_{k}\left[\sum_{i=0}^{n}\sum_{j=0}^{n-i}\sum_{k=0}^{n}\sum_{l=0}^{n-k}a_{ij}a_{lk}x^{k+i}y^{l+j}\right]$$

$$-2\sum_{k}M(x,y)-\sum_{i=0}^{n}\sum_{j=0}^{n-i}a_{ij}x^{i}y^{j}+\sum_{k}M^{2}(x,y) \qquad (5)$$

The least-squares conditions demand that the derivative of the coefficients a_{ij} with respect to **I** be zero, i.e

$$\frac{\partial I}{\partial a_{ij}}=0 \qquad (6)$$

This gives (6) as

$$\sum_{k=0}^{n}\sum_{l=0}^{n-k}a_{lk}\sum_{k}x^{k+i}y^{l+j}=\sum_{k}Mx^{i}y^{j} \qquad (7)$$

On the case at hand there was a little deviation from this method. The problem was tackled by digitizing the trend surface, at regular intervals to obtain the trend values. These values were subtracted from the observed magnetic values. The resulting graph is the residual.

Application To A Magnetic Field Data

The magnetic field data used in this study was originally collected and examined by Igboama (2005). The base map of the area, from which the data was obtained, is shown in fig. 1 and the ground magnetic map is shown in fig.2 with its corresponding 3D perspective view. The geology of the area, fall within southwestern Nigeria Basement Complex.

The surface fitting was applied to the field data, by fitting a trend to the observed (relative) magnetic profiles using a personal computer. The trends obtained were digitized at regular intervals to obtain the regional values. Hence, the residualized data were obtained by subtracting the regional values from the relative magnetic (observed) values. The various profiles obtained are as shown in fig.3 (a-r). Several degrees of polynomials were tested and the fourth order, which correlated favourably with the ground magnetic contoured map, was chosen, that is, superposing the regional (trend) map of the total component (fig.4) with the ground magnetic map (fig.2) obtained after contouring using "Surfer" package.

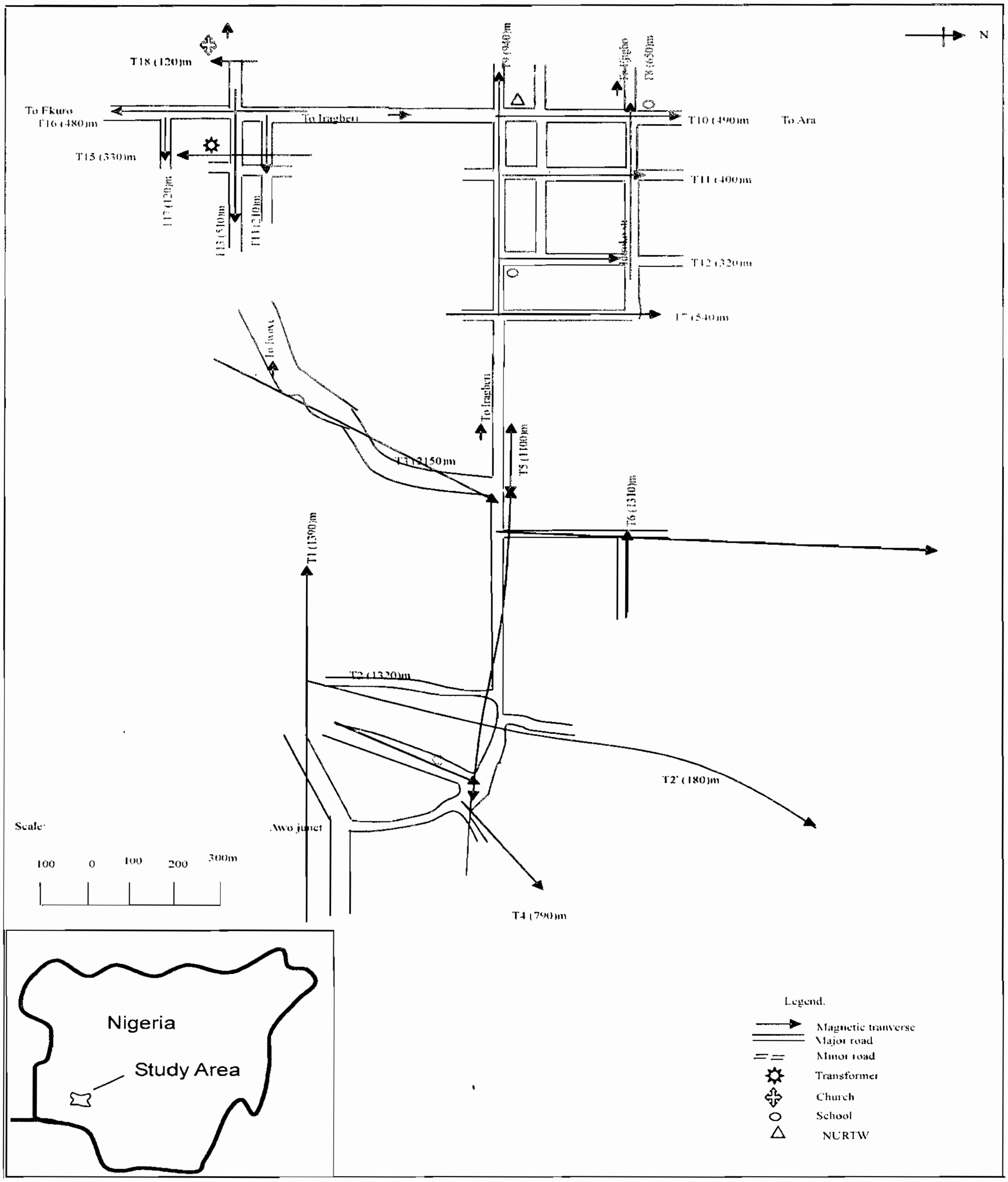


Fig.1: Basemap of Awo, Iwoye and Iragberi with Nigeria as an Inset.

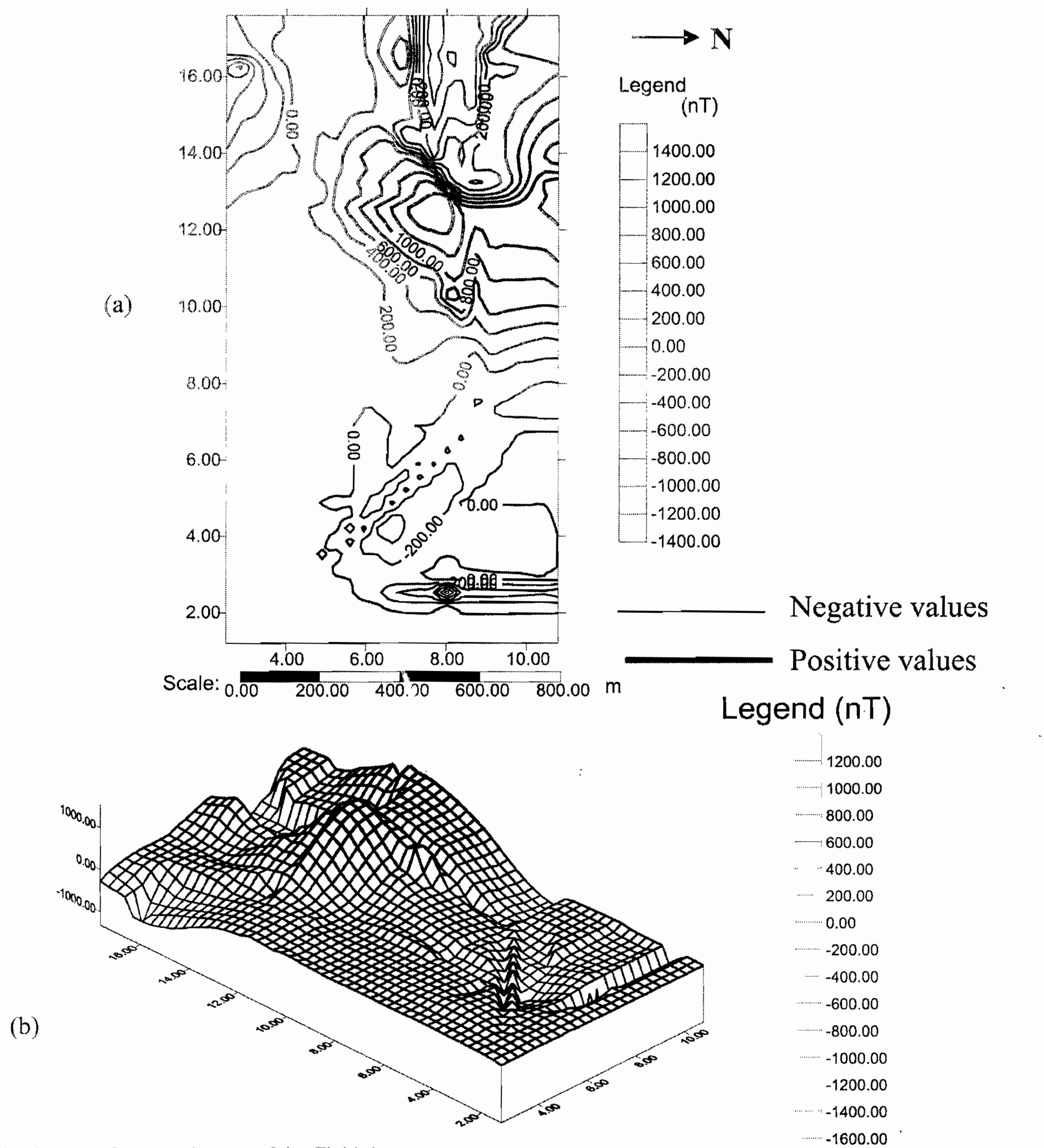


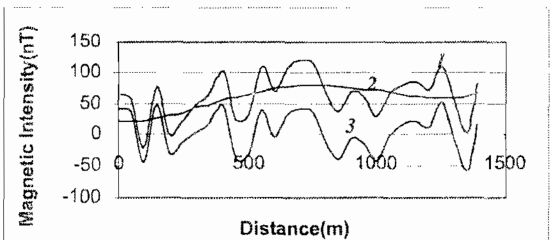
Fig. 2:(a) Ground magnetic map of the Field data.
(b) 3-D Perspective view of the Ground magentic map

Discussion of Results

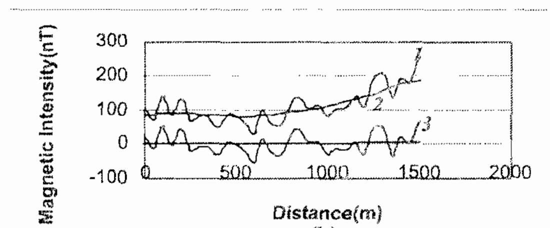
Figure 3 revealed that in most cases the profiles obtained in ground magnetic were as a result of the anomalous bodies except in few cases, particularly, with fig.3 (g,i,j,l), that is, traverses 7,9,10 and 12 respectively where the observed profiles may be a joint consequence of the regional effect and mineralization. Fig.5a is the residual map of the area obtained using a trend of fourth order polynomial of the total field. The figure also depicted the location of tantalite deposit at Awo at the point marked x. The presence of tantalite and associate minerals were also noticed in the southeast direction where pockets of enclosures were obtained with a particular pattern and a particular trend. The map revealed that the low at Iragberi might be as a result of mineral deposit and geologic formation (trend). The residual map (Fig.5a) showed that the magnetic high at traverses 7, and 12 were due to regional effects because the residuals here oscillate between negative 150nT and positive 150nT. Thus according to Odeyemi et al (1997), high relative intensity values may indicate deep structures, which may be, due to block faulting.

Pattern recognition of the profiles (fig.3) with Telford et al (1990), Reynolds (2001) showed that the study area especially the northeast and northwest were mainly faulted zones. Particularly traverses 4 and 5 where the tantalite deposit is and traverses 9 and 10 were mainly as a result of fractures and faults. This was also shown by the 3D perspective view (fig2b) of the area. Also traverses 9 and10 showed magnetic interference pattern, which may be due to anomalies.

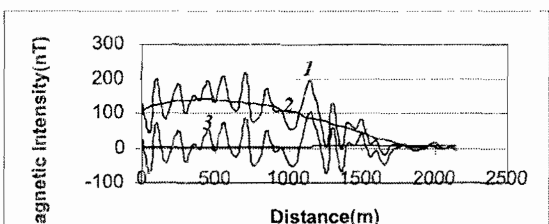
Figure 5b is the three-dimensional view of the residual anomaly of the total magnetic field using fourth order polynomial of the study area. The negative anomaly that appeared on the southeastern part which trends towards northwest is another suspected area of mineral deposit (tantalite), which was not considered by Igboama (2005). The magnetic low observed at the west end of the map could be due to regional effect suggesting possibility of a fault and the interference pattern of an anomaly. The positive high magnetic intensity values obtained around the west central were also shown to be due to the geologic formation (deep seated structure) and not necessarily by minerals of high magnetic intensity as depicted by the ground magnetic map. Traverse 17 at Iwoye (southwest) of the study area with relative low magnetic intensity values may be due to geologic formation because surface trend here has high negative intensity values.



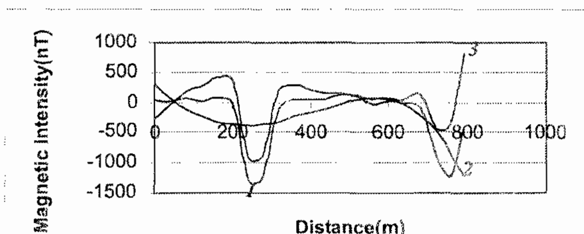
(a)



(b)



(c)



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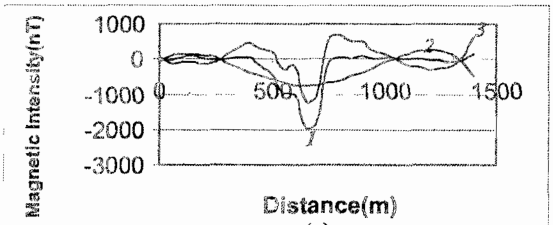

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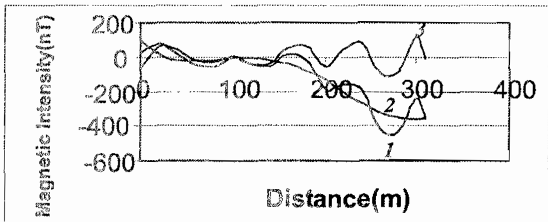

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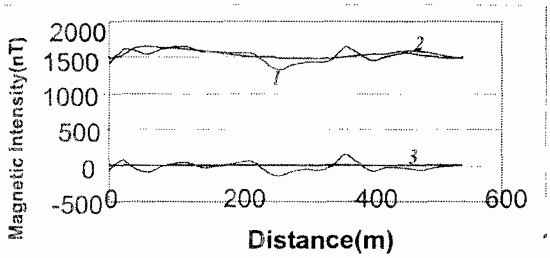
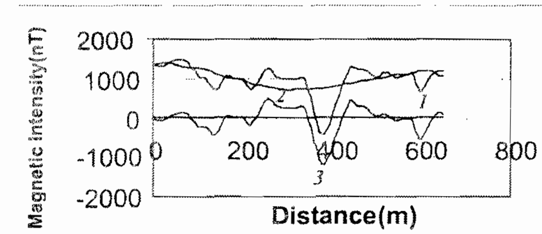


(g)



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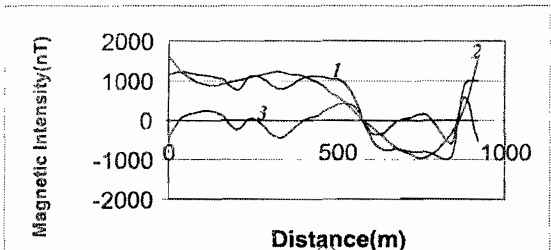
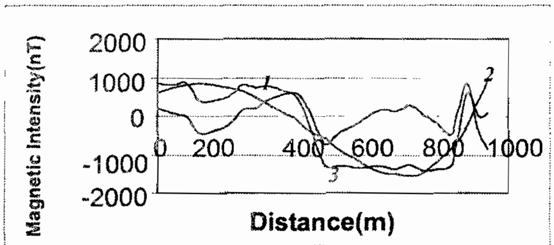


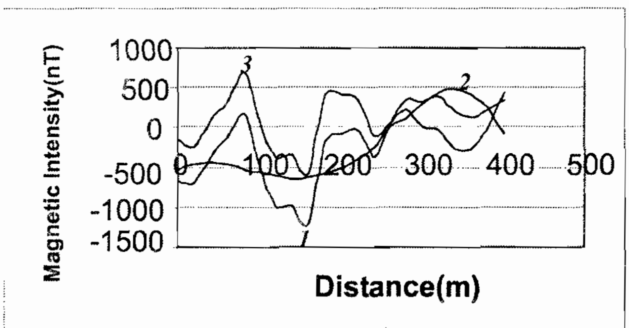
(i)



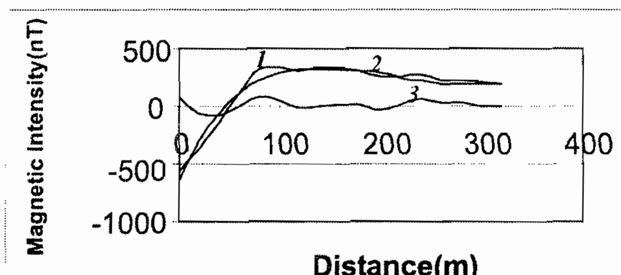
(j)

LEGEND

1	Observed
2	Trend
3	Residual



(k)



(l)

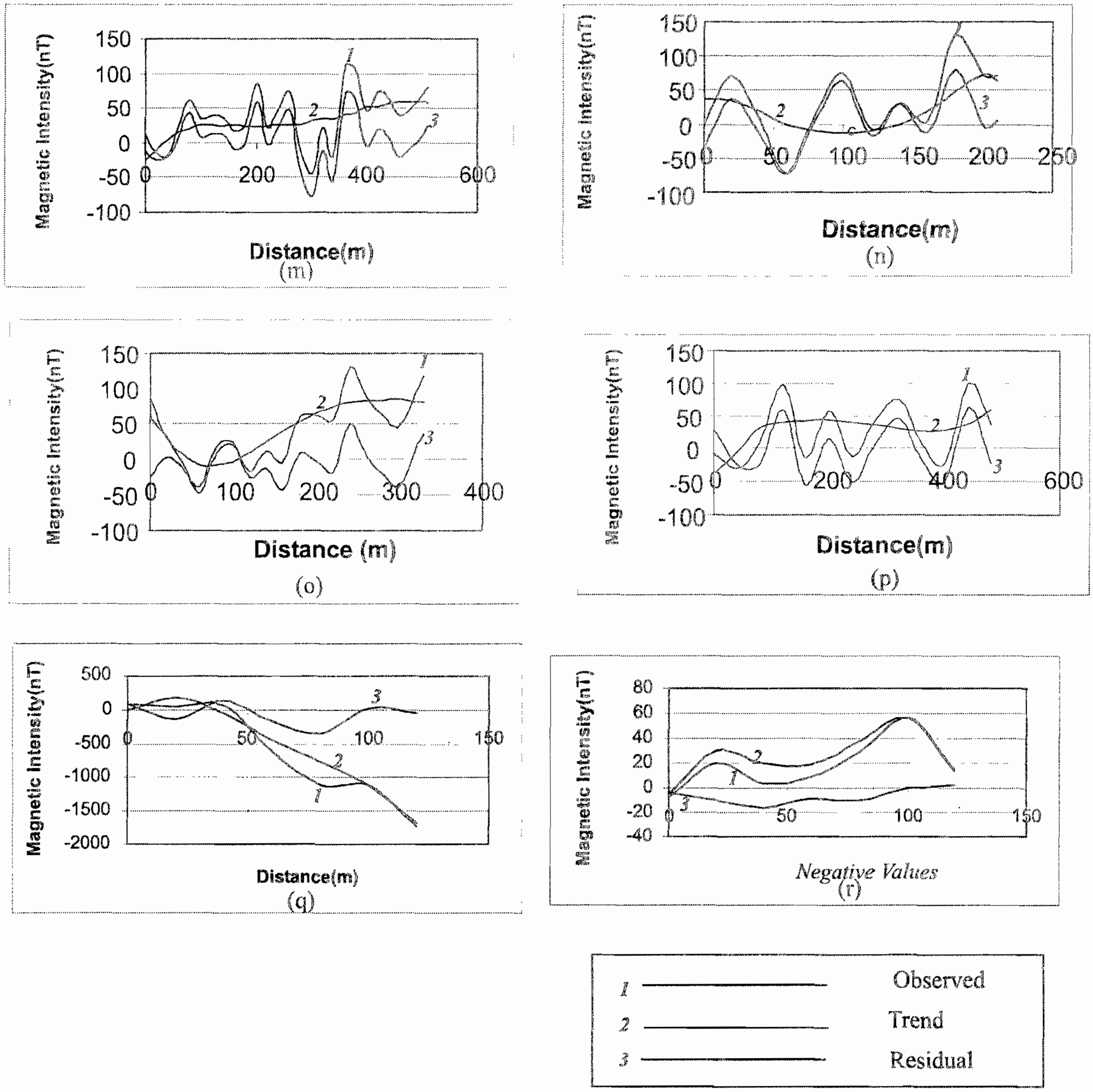


Fig.3: Residual profiles along Traverses 1-18 (a-r) respectively.

Conclusion

The fourth order degree polynomial surface of the ground magnetic field (fig.4) represents the surface that best describes the regional magnetic background of the area. In dealing with the interpretation, emphasis was on residual anomaly. With the application of trend surface analysis using fourth order polynomial to the total field, the presence of tantalite and associate minerals was established. This shows the applicability of the above technique as a good tool in magnetic data interpretation.

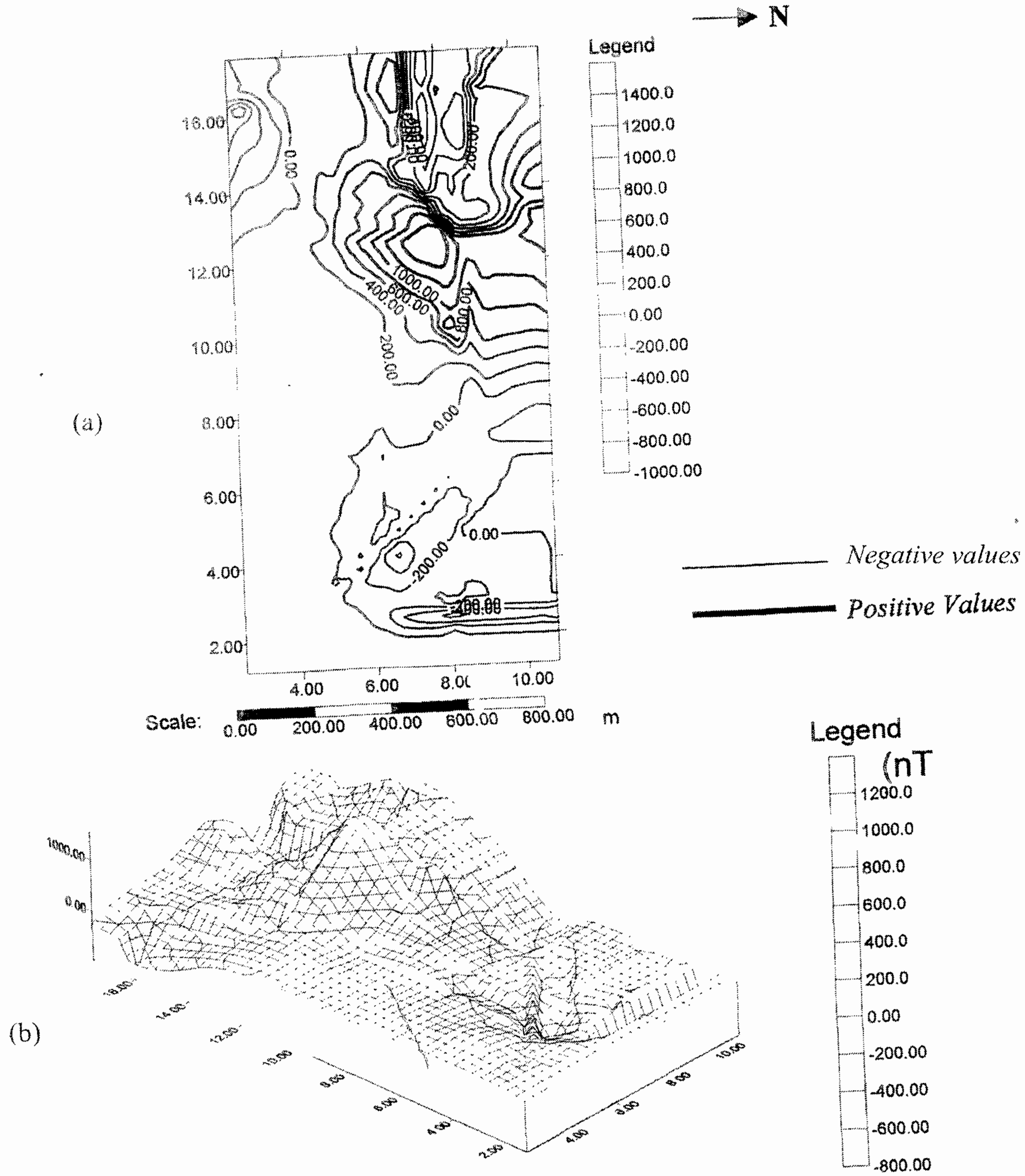


Fig.4:(a) Trend Map of the Area using Fourth Order Polynomial Fitting.
(b)3-D Perspective view of the Trend map.

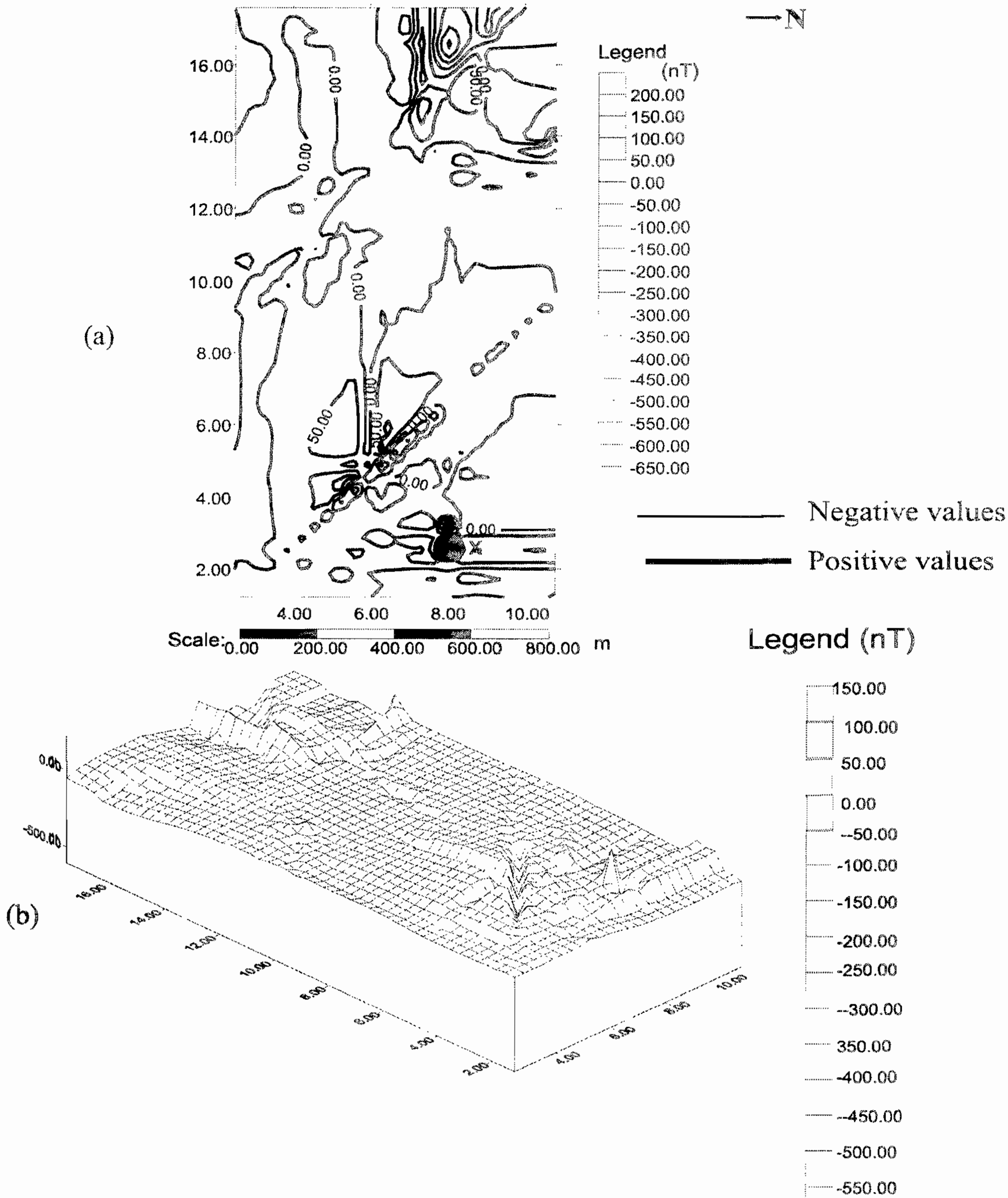


Fig.5: (a) Residual map of the area

(b) 3-D Perspective view of the residual map.

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