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Simple Models for the Interpretation of Magnetic Anomalies Due to Remanence in Magnetic Equator

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Abstract: Magnetization due to remanence of magnetic sources in the earth's field in equatorial belt (magnetic equator) may be analysed using simple models. The models are magnetic signatures with low in the north flanked by magnetic high in the south (point pole) and isolated magnetic high (point dipole). The model is based on the effect of dyke magnetized due to remanence in the earth's field because of the suitability of dyke-like bodies in the most geological situations. In the model to obtain the resolved direction of the remanent component (I_r), β (amplitude ratio), F_{max} (maximum amplitude), F_{min} (minimum amplitude) and θ (index parameter) must be evaluated. To test the applicability of the models, aeromagnetic data from part of Niger Delta basin of Nigeria and the adjacent geological province (Calabar Flank) were analysed. The result show that the resolved direction of remanent component of the magnetic field is in the neighbourhood of 260°/-100°. This result has application in paleomagnetic study. From the magnetic data sets, detrital and thermal remanent magnetization were inferred. The detrital remanence is probably due to great thickness of sedimentation in the delta while the source of the thermal remanence in the adjacent Calabar Flank suggest wide spread igneous intrusions which has subjected the Flank to high temperature. The intrusives are identified in the magnetic data by linearments. The linearment indicate structural features that have controlled the tectonic expression of the Flank. Therefore, correlation can be established between remanence, tectonism and paleomagnetism.

Key words: Magnetization, dipole, remanence, paleomagnetism

INTRODUCTION

Many Interpretational techniques have been applied to geomagnetic data by geomagnetisians. The various techniques can be summarized into different groups. They include: the Spectral analysis technique e.g., Hahn *et al.* (1976), Ofoegbu and Onuoha (1991), Fedi *et al.* (1997), Kangkolo *et al.* (1997) and Nwogbo *et al.* (1991); Graphical method e.g., Bean (1966), Powell (1965) and Odia (1990); Werner-based deconvolution technique e.g., Umego *et al.* (1995) and curve matching technique e.g., Gay (1963), Hutchison (1958) and Telford *et al.* (1976).

Most of these techniques are based on the fact that magnetizations are due to induction in the earth's field. Measurement of remanent magnetic component of a rocks can be carried out in the laboratory. The analyses of samples in the laboratory is usually expensive and takes a lot of time. Owing to these 2 factors, geomagnetisians assume that there is no remanent component in the observed magnetic field. This assumption is not very correct. The interpretational models presented in this paper are based on the premise that magnetization is due to remanence (permanent magnetization created by the earth's magnetic field during some process in the history of formation of the magnetic source) (Nwankwo *et al.*, 2006).

Therefore, the objective of this study is to provide alternative method for paleomagnetic studies by interpreting remanent magnetization and its direction from geomagnetic data in magnetic equator without resorting to laboratory analysis of rock samples. Measurement of the orientation of the permanent magnetization of rocks provides the basis for paleomagnentic measurements (Breiner, 1973).

The geology of the study area shows that the Tertiary sedimentary fill of the Niger Delta basin shows all overall upward and updip transition (Ejedawe *et al.*, 1984) from marine prodelta shales (Akata Formation) through an alternating sand/shale paralic interval (Agbada Formation) to continental sands (Benin Formation) (Fig. 1). The total sedimentary sequence (greater than 8,000 m) was deposited in a series of megasedimentary belts (or depobelts) in succession in time and space with southward progradation of the delta. Five major depobelts can be distinguished along the north-south axis of the delta. These mega units range in width from about 30-60 km and each is broken by a series of en echelon

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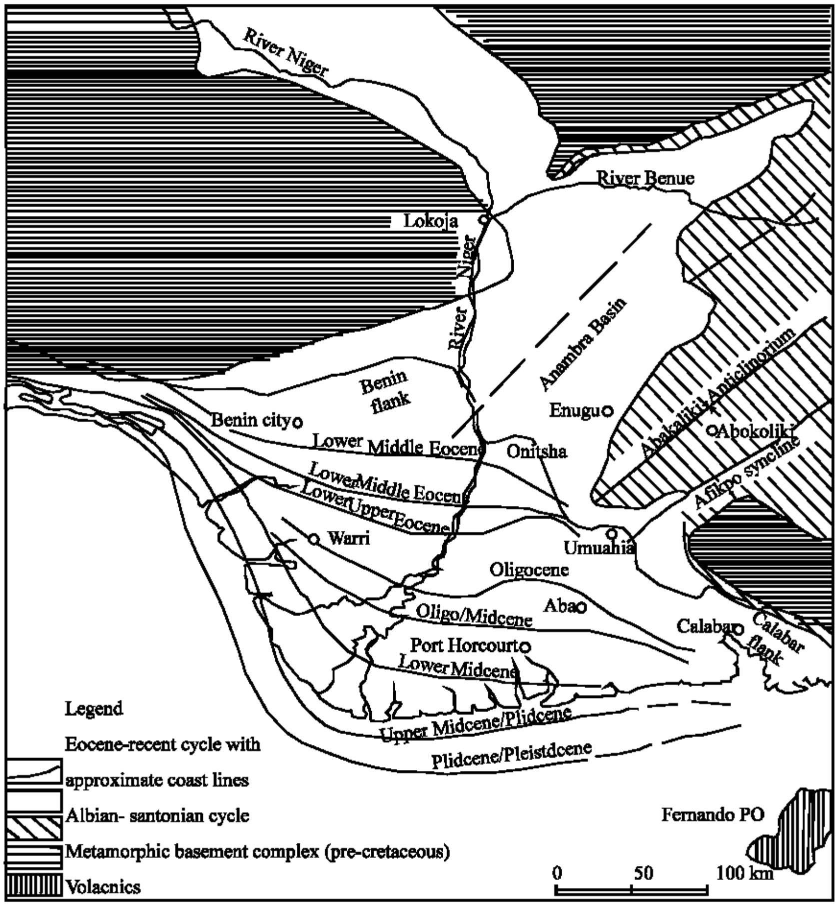

Fig. 1: General geological map of the Niger Delta and environs

growth faults. In the eastern delta, these depobelts are subdivided into dual units apparently as a result of the bifurcation of the major bounding faults. Within the depobelts, both the Akata and Agbada Formations are thought to have served to varying degrees as oil and gas source rocks.

The adjoining Coastal basin (Calabar Flank) has detailed geological and stratigraphic sequence compiled by Edet and Nyong (1993) and Peters (1982). It shows that Calabar Flank consists of basal Fluvio-deltaic grits and sandstones of the Awi Formation (Aptian-Albian); limestone and calcareous sandstones of the Mfamosing Formation (mid-late Albian); alternating limestone and shales of the Odukpani Formation (Cenomanian); shales and m arls of the Eze-Aku Formation (Turonian); marls of the AwguFormation (Coniacian) and carbona-ceous shales of the Nkporo shales (Campanian-Maastrichtians).

MATERIALS AND METHODS

Fundamental concept of the model: In equatorial belt (magnetic equator) where the earth's magnetic field is horizontal, there are 2 magnetic signatures that can be obtained from magnetic data. Magnetic high in the north flanked by low in the South (Fig. 2a) and a dominant low (Fig. 2b). The 2 signatures are due to normal induction in the earth's field in magnetic equator. If magnetization is however due to remanence, the magnetic signatures will assume different orientation. That is a low in the north flanked by high in the south (Fig. 2c). Remanence can also be suspected if there is isolated high in magnetic data and the signature will assume the shape in Fig. 2d.

Figure 2c approximates a N-S Cylinder (point pole). It represents a dyke-like body of infinite thickness in the subsurface (Fig. 3a). That is igneous intrusives of infinite thickness. In magnetic data this is recognized as magnetic Contours of low and high adjacent to each other. Figure 2d is approximated as a sphere (point dipole) (Fig. 3b) as if the sphere is a magnetic source in higher latitude (polar region) and the model contours are recognized as dyke of isolated magnetic high in magnetic data.

The overriding factors which point to any of the applicable models due to remanent magnetization are the inclination of the ambient field and the dimension of the source.

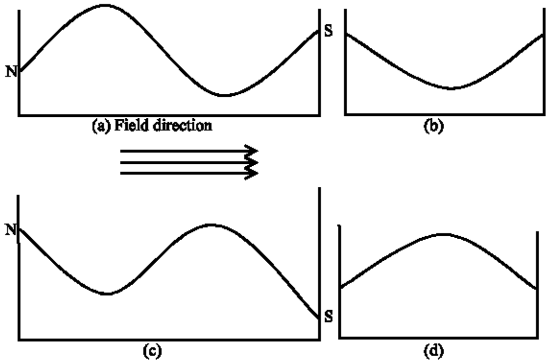

Fig. 2: (a) and (b) are signatures due to normal induction in the earth's fields (After Breiner, 1973) (c) and (d) are model signatures due to remanence

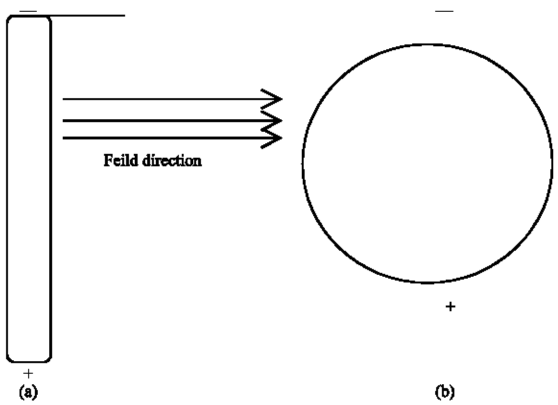

Fig. 3: (a) N-S Cylinder (Point Pole), (b) Sphere (Point dipole)

Model equations: The magnetic model is based on the effect of a dyke magnetized due to remanence in the earth's field. The model parameters are shown in Fig. 4 and the equations are after Ram Babu *et al.* (1986) with slight modifications.

The usual expression for magnetic anomaly (ΔF) of dyke-like origin at any point P(x) on the x-axis is:

$$\Delta F(x)=A\left[\begin{array}{l}\cos\theta\left(\tan^{-1}\frac{x+b}{h}-\tan^{-1}\frac{x-b}{h}\right)\\ +\frac{1}{2}\sin\theta\log_e\frac{(x+b)^2+h^2}{(x-b)^2+h^2}\end{array}\right] \tag{1}$$

Where,

A = Amplitude coefficient.
θ = Index parameter.
h = Depth to the top of the dyke.
b = The width.

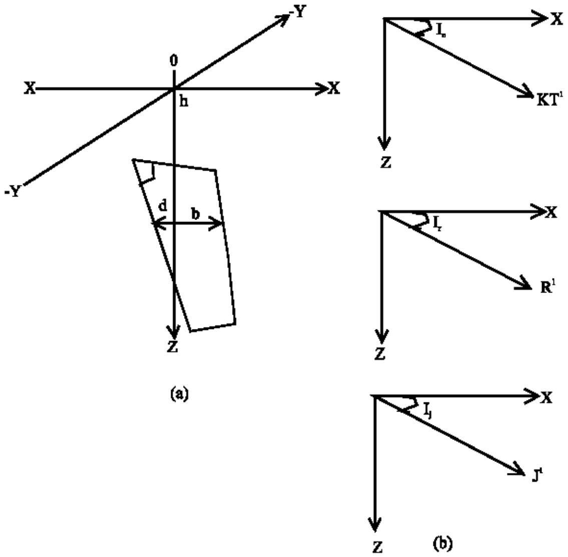

Fig. 4: (a) Cross-sectional view and (b) Magnetization vectors in the XZ plane of the dyke (Ram Babu *et al.*, 1986).

Where, d = Is the dip of the dyke. The strike of the dyke is along the Y-axis while a meridional magnetic profile is along the x-axis.

I_e, I_r and I_j are the resolved directions of the induced (KT'), remanent (R') and resultant (J') Components of magnetization in the XZ plane, respectively.

When the dyke is magnetized due to remanence:

$$I_r = I_j \tag{2}$$

$$I_e = \arctan(\tan i_e / \cos D_e) \tag{3}$$

Where,

i_e = Angle of inclination of the earth's magnetic field (negative in the southern hemisphere).
D_e = Angle between the magnetic north and the positive x-axis.

$$I_j = \theta - I_e + d + 90° \text{ for a } \Delta T \text{ anomaly} \tag{4}$$

$$= \theta + d + 90° \text{ for a } \Delta H \text{ anomaly} \tag{5}$$

For a vertically dipping bodies for example, igneous dyke, d is eliminated from Eq. (4) and (5).

$$\text{i.e } I_j = \theta - I_e + 180° \text{ for a } \Delta T \text{ anomaly} \tag{6}$$

$$= \theta + 180° \text{ for a } \Delta H \text{ anomaly} \tag{7}$$

where, ΔT and ΔH are total field and horizontal field anomalies.

$$\beta = \frac{F_{max}}{F_{min}} \quad (8)$$

where, β, F_{max} and F_{min} are amplitude ratio, maximum amplitude and minimum amplitude, respectively.

Application: To test the applicability of the models, total magnetic intensity data published by the Geological Survey of Nigeria for the Niger Delta and the environs were used. The basin is an instructive area for this investigation because of the presence of remanent magnetization of rocks in the geological province. Ananaba (1980) published predicted values and annual changes of geomagnetic elements in Nigeria. The predicted values (Table 1-3) of Ananaba (1980) and the values of angle of magnetic field inclinations (i_e) published along with the total intensity data by geological survey of Nigeria were used for the analyses.

Table 1: A1° × 1° Prediction of mean values (a) total magnetic intensity (F) in Gammas (After Ananaba, 1980)

	Longitude °E													
Latitude °N	2	3	4	5	6	7	8	9	10	11	12	13	14	15
14	33593	33695	33798	33903	34008	34114	34220	34237	34434	34541	34648	34754	34860	34965
13	33308	33411	33516	33621	33728	33835	33942	34050	34158	34265	34373	34482	34586	34692
12	33042	33148	33254	33361	33469	33577	33685	33794	33902	34011	34119	32226	34333	34439
11	32798	32905	33013	33121	33230	33340	33449	33559	33668	33777	33886	33994	34101	34207
10	32575	32684	32793	32903	33013	33124	33235	33345	33455	33565	33674	33783	33891	33997
9	32373	32483	32594	32706	32817	32929	33041	33153	33264	33374	33484	33593	33702	33808
8	32191	32303	32416	32529	32642	32755	32868	32981	33093	33205	33315	33425	33533	38641
7	32029	32143	32257	32372	32486	32601	32715	32829	32942	33055	33166	33277	33386	33493
6	31885	32001	32117	32234	32350	32466	32582	32697	32811	32924	33037	33148	33257	33365
5	31759	31877	31995	32113	32231	32349	32466	32582	32698	32812	32925	33037	33147	33255
4	31649	31769	31890	32009	32129	32248	32366	32484	32601	32716	32830	32942	33053	33161

(b) annual changes in Gammas per Year in Nigeria (After Ananaba, 1980)

14	11.2	11.9	12.6	13.2	13.7	14.1	14.5	14.8	15.1	15.2	15.3	15.3	15.2	15.0
13	11.5	12.3	12.9	13.5	14.0	14.4	14.8	15.0	15.2	15.3	15.4	15.3	15.2	15.0
12	12.0	12.7	13.3	13.8	14.3	14.7	15.1	15.3	15.5	15.5	15.5	15.5	15.3	15.0
11	12.4	13.1	13.7	14.2	14.7	15.1	15.4	15.6	15.7	15.8	15.7	15.6	15.4	15.1
10	12.9	13.6	14.2	14.7	15.1	15.5	15.7	15.9	16.0	16.0	15.9	15.8	15.5	15.1
9	13.4	14.1	14.6	15.1	15.5	15.9	16.1	16.2	16.3	16.3	16.1	15.9	15.6	15.2
8	13.9	14.6	15.1	15.6	16.0	16.3	16.5	16.6	16.6	16.5	16.4	16.1	15.7	15.2
7	14.5	15.1	15.6	16.0	16.4	16.6	16.8	16.9	16.9	16.8	16.6	16.2	15.8	15.3
6	15.0	15.5	16.0	16.4	16.8	17.0	17.2	17.2	17.1	17.0	16.7	16.3	15.9	15.3
5	15.4	16.0	16.4	16.8	17.1	17.3	17.4	17.4	17.3	17.1	16.8	16.4	15.8	15.2
4	15.8	16.3	16.8	17.1	17.4	17.6	17.6	17.6	17.5	17.2	16.8	16.4	15.8	15.0

Table 2: A 1°× 1°Prediction of mean values of (a) east declination (D) in degrees and minutes (After Ananaba, 1980)

	Longitude °E													
Latitude °N	2	3	4	5	6	7	8	9	10	11	12	13	14	15
14	-5°19’	-5°03’	-4°48’	-4°33’	-4°19’	-4°05’	-3°52’	-3°40’	-3°28’	-3°17’	-3°06’	-2°55’	-2°45’	-2°34’
13	-5°31’	-5°15’	-4°60’	-4°45’	-4°30’	-4°17’	-4°04’	-3°51’	-3°39’	-3°28’	-3°17’	-3°06’	-2°55’	-2°45’
12	-5°44’	-5°28’	-5°12’	-4°57’	-4°43’	-4°29’	-4°16’	-4°03’	-3°51’	-3°39’	-3°28’	-3°17’	-3°06’	-2°56’
11	-5°58’	-5°41’	-5°26’	-5°10’	-4°56’	-4°42’	-4°29’	-4°16’	-4°04’	-3°52’	-3°40’	-3°29’	-3°18’	-3°08’
10	-6°12’	-5°56’	-5°40’	-5°24’	-5°10’	-4°56’	-4°42’	-4°29’	-4°17’	-4°04’	-3°53’	-3°41’	-3°30’	-3°19’
9	-6°28’	-6°11’	-5°55’	-5°39’	-5°24’	-5°10’	-4°56’	-4°43’	-4°30’	-4°18’	-4°06’	-3°54’	-3°43’	-3°32’
8	-6°44’	-6°27	-6°10’	-5°55’	-5°39’	-5°25’	-5°11’	-4°57’	-4°44’	-4°32’	-4°20’	-4°08’	-3°56’	-3°45’
7	-7°01’	-6°45’	-6°27’	-6°11’	-5°55’	-5°41’	-5°26’	-5°13’	-4°59’	-4°47’	-4°34’	-4°22’	-4°10’	-3°58’
6	-7°18’	-7°01’	-6°44’	-6°28’	-6°12’	-5°57’	-5°43’	-5°29’	-5°15’	-5°02’	-4°49’	-4°37’	-4°24’	-4°12’
5	-7°31’	-7°19’	-7°02'	-6°46’	-6°30’	-6°15’	-6°00’	-5°46’	-5°32’	-5°18’	-5°05’	-4°52’	-4°40’	-4°27’
4	-7°56’	-7°31’	-7°21’	-7°04’	-6°48’	-6°33’	-6°18’	-6°03’	-5°49’	-5°35’	-5°22’	-5°08	-4°55’	-4°43’

(b) annual changes in minutes per year in Nigeria (After Ananaba, 1980)

14	4.5	4.4	4.4	4.3	4.2	4.1	4.1	4.1	4.0	4.0	4.0	4.0	4.0	3.9
13	4.5	4.3	4.3	4.2	4.2	4.1	4.1	4.0	4.0	4.0	4.0	4.0	4.0	4.0
12	4.5	4.3	4.3	4.2	4.2	4.1	4.1	4.0	4.0	4.0	4.0	4.0	4.0	4.0
11	4.4	4.2	4.2	4.2	4.1	4.1	4.1	4.0	4.0	4.0	4.0	4.0	4.1	4.1
10	4.4	4.2	4.2	4.2	4.1	4.1	4.1	4.0	4.0	4.0	4.1	4.1	4.1	4.1
9	4.3	4.2	4.2	4.1	4.1	4.1	4.0	4.0	4.0	4.1	4.1	4.1	4.1	4.2
8	4.3	4.2	4.2	4.1	4.1	4.1	4.0	4.0	4.1	4.1	4.1	4.2	4.2	4.2
7	4.2	4.1	4.1	4.1	4.1	4.0	4.0	4.1	4.1	4.1	4.2	4.2	4.3	4.3
6	4.2	4.1	4.1	4.1	4.1	4.0	4.1	4.1	4.1	4.1	4.2	4.2	4.3	4.4
5	4.2	4.1	4.1	4.1	4.0	4.0	4.1	4.1	4.1	4.2	4.2	4.3	4.4	4.4
4	4.2	4.1	4.1	4.0	4.0	4.1	4.1	4.1	4.2	4.2	4.3	4.4	4.4	4.5

Airborne magnetic maps which cover wider area and show prominent regional deeper features is more suitable to test the applicability of the models.

The examples illustrated in Fig. 5-10 show the potential use of anomaly analyses as basis for paleomagnetic studies especially if the anomaly maximum and minimum are prominent. In Fig. 5, the elliptical magnetic low northwest is isolated. This is an induced magnetization (Fig. 2b). The high Flanked by low in the northeast corner is also induced magnetization (Fig. 2a). Analyses of the data set (Fig. 5) show that if a profile is taken orthogonal to the contours of the magnetic low in

Table 3: A 1° × 1°Prediction of mean values of (a) north inclination (I) in degrees and minutes (After Ananaba, 1980)

	Longitude E°													
Latitude °N	2	3	4	5	6	7	8	9	10	11	12	13	14	15
14	8°47'	8°46'	8°44'	8°44'	8°44'	8°44'	8°44'	8°45'	8°46'	8°47'	8°49'	8°51'	8°53'	8°55'
13	6°23'	6°21'	6°20'	6°19'	6°18'	6°18'	6°18'	6°18'	6°19'	6°20'	6°21'	6°23'	6°25'	6°26'
12	3°58'	3°56'	3°54'	3°52'	3°51'	3°51'	3°50'	3°51'	3°51'	3°52'	3°52'	3°54'	3°55'	3°57'
11	1°32'	1°29'	1°27'	1°25'	1°23'	1°22'	1°22'	1°22'	1°22'	1°22	1°22'	1°23'	1°24'	1°26'
10	-54'	-58'	-1°01'	-1°03'	-1°05'	-1°06'	-1°07'	-1°08'	-1°08'	-1°09'	-1°08'	-1°08'	-1°07'	-1°06'
9	-3°21'	-3°25'	-3°28'	-3°31'	-3°34'	-3°36'	-3°37'	-3°38'	-3°39'	-3°39'	-3°39'	-3°39'	-3°39'	-3°38'
8	-5°48'	-5°52'	-5°56'	-6°00'	-6°02'	-6°05'	-6°07'	-6°08'	-6°09'	-6°10'	-6°11'	-6°11'	-6°11'	-6°10'
7	-8°14'	-8°19'	-8°23'	-8°27'	-8°31'	-8°33'	-8°36'	-8°38'	-8°39'	-8°41'	-8°41'	-8°42'	-8°42'	-8°42'
6	-10°39'	-10°45'	-10°50'	-10°54'	-10°58'	-11°01'	-11°04'	-11°07'	-11°09'	-11°10'	-11°12'	-11°13'	-11°13'	-11°13'
5	-13°03'	-13°09'	-13°15'	-13°20'	-13°24'	-13°28'	-13°31'	-13°34'	-13°37'	-13°39'	-13°41'	-13°42'	-13°43'	-13°44'
4	-15°26'	-15°33'	-15°39'	-15°44	-15°49'	-15°53'	-15°57'	-16°01'	-16°03'	-16°06'	-16°08'	-16°10'	-16°11'	-16°12'

(b) annual changes in minutes per year in Nigeria (After Ananaba, 1980)

14	-6.5	-6.4	-6.2	-6.1	-6.0	-5.9	-5.8	-5.6	-5.5	-5.4	-5.3	-5.1	-5.0	-4.8
13	-6.8	-6.6	-6.5	-6.4	-6.6	-6.1	-6.0	-5.9	-5.8	-5.7	-5.5	-5.4	-5.3	-5.1
12	-7.0	-6.9	-6.8	-6.6	-6.5	-6.4	-6.3	-6.2	-6.1	-5.9	-5.8	-5.7	-5.5	-5.4
11	-7.2	-7.1	-7.0	-6.9	-6.8	-6.7	-6.6	-6.5	-6.3	-6.2	-6.1	-6.0	-5.8	-5.7
10	-7.5	-7.4	-7.3	-7.1	-7.0	-6.9	-6.8	-6.7	-6.6	-6.5	-6.4	-6.2	-6.1	-5.9
9	-7.7	-7.6	-7.5	-7.4	-7.3	-7.2	-7.1	-7.0	-6.9	-6.8	-6.6	-6.5	-6.4	-6.2
8	-8.0	-7.8	-7.7	-7.6	-7.5	-7.4	-7.3	-7.2	-7.1	-7.0	-6.9	-6.8	-6.6	-6.5
7	-8.2	-8.1	-8.0	-7.9	-7.8	-7.7	-7.6	-7.5	-7.4	-7.3	-7.2	-7.0	-6.9	-6.7
6	-8.4	-8.3	-8.2	-8.1	-8.0	-7.9	-7.8	-7.7	-7.6	-7.5	-7.4	-7.3	-7.1	-7.0
5	-8.6	-8.5	-8.4	-8.3	-8.2	-8.2	-8.1	-8.0	-7.9	-7.8	-7.6	-7.5	-7.4	-7.2
4	-8.8	-8.7	-8.6	-8.5	-8.5	-8.4	-8.3	-8.2	-8.1	-8.0	-7.9	-7.7	-7.6	-7.4

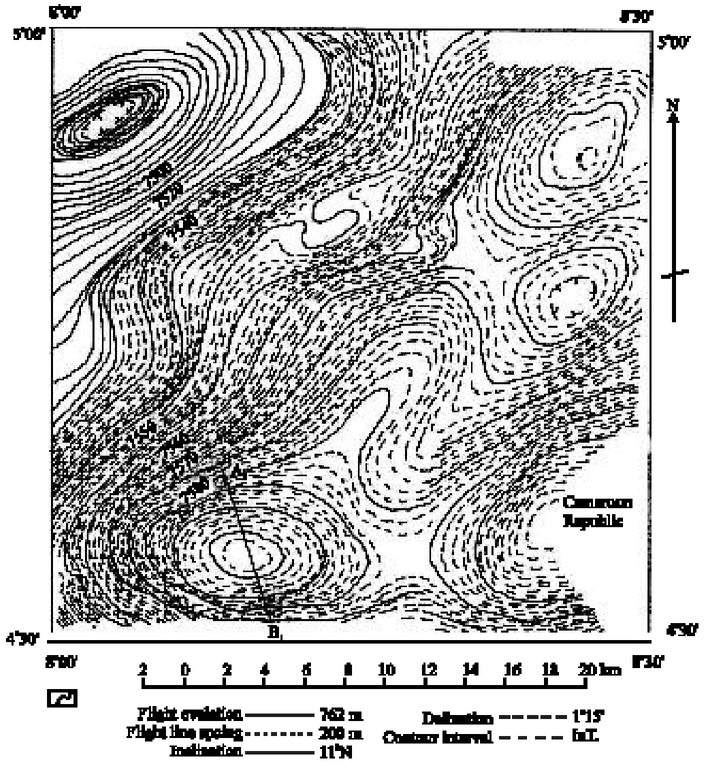

Fig. 5: Magnetic Anomalies in Calabar flank with both remances and induced magnetization

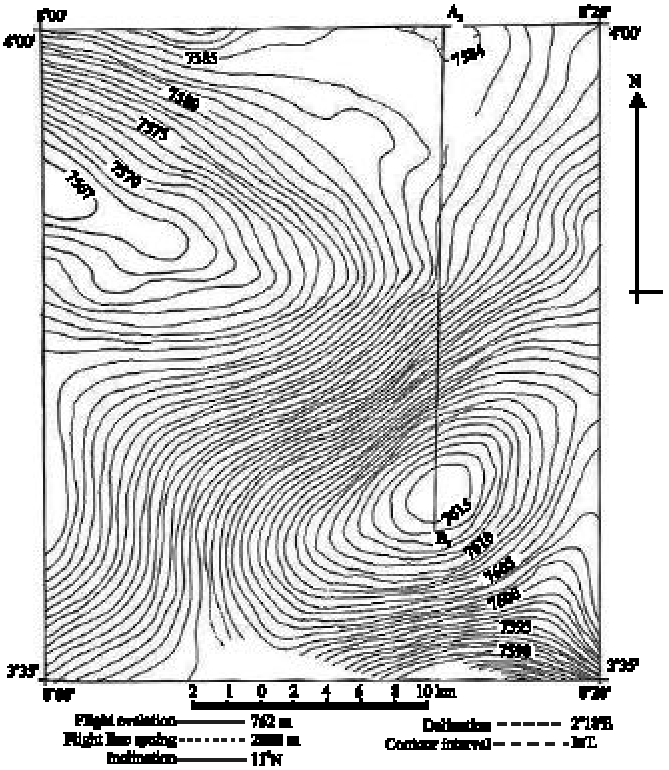

Fig. 6: The aeromagnetic anamaly with remananence in Niger Delta Basin and adjioning offshore

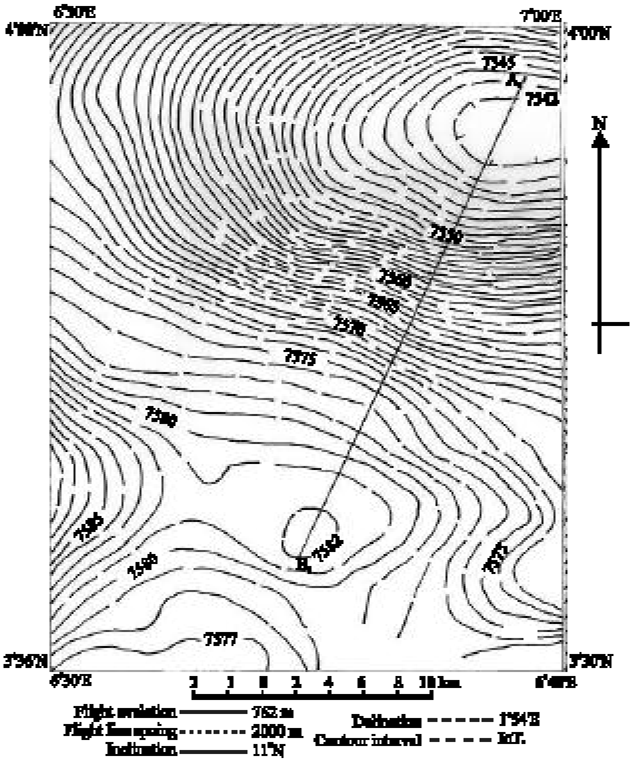

Fig. 7: Remance offshore Niger delta Basin

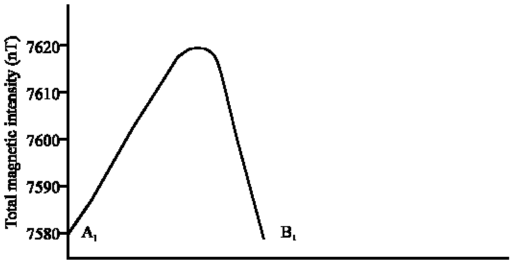

Fig. 8: Interpretation of profile A_1- B_1

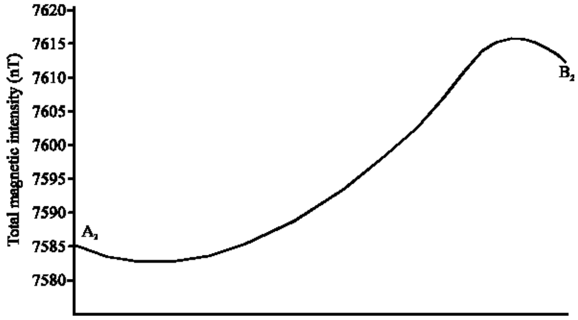

Fig. 9: Interpretation of profile A_2- B_2

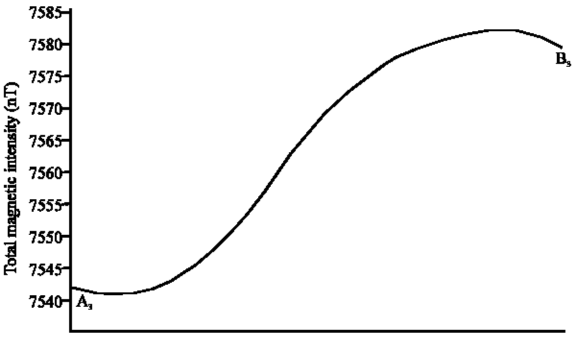

Fig. 10: Interpretation of profile A_3- B_3

the northwest and high in the southwest an irregular magnetic signature is obtained. Therefore, the circular magnetic high southwest is also isolated. This is due to remanence (Fig. 2d). Profiles A_2-B_2 and A_3-B_3 translate to the magnetic signature of Fig. 2c (remanance).

Equation (3) and (6) gave the values of I_e and I_j, respectively.

The index parameter (θ) could be obtained from the nomogram of Ram Babu *et al.* (1986) showing the variation of β with θ.

RESULTS AND DISCUSSION

The isolated magnetic high (remanence) in Fig. 5 southwest of Calabar Flank modeled as point dipole (Fig. 3b) is a lineament with distinctive trends, prominently oriented in E-W direction. This lineament indicates structural features that pre-date exposed geology and that have controlled the tectonic expression of the Flank. There is continuity of the lineaments into the adjacent Oban Massif (basement). This suggests that the tectonics in Calabar Flank pre-date the emergence of major tectonic elements (Ikang trough and Ituk high) in the area (Okiwelu *et al.*, 2002). Thus correlation can be established between remanence, tectonism and paleomagnetism.

The source of the isolated circular magnetic anomaly is an intrusive body. Intrusives are defined by circular contours in geophysical maps (Akanbi and Udensi, 2006). Gravity modeling by Okiwelu (2007) shows that the Flank is characterized by intrusive bodies originating from dyke intrusion occurring probably during the initial stage of rifting in the Flank. This gave a gravity high. Evidences from measured density values (Ugbaja, 2007) and gravity modeling show that the source is basaltic (gabbro) with a density of 2.87 g cm^{-3}. Intrusive bodies are well documented by Ekwueme (2003) from the adjacent Oban Massif and Kangkolo (1995) from the adjacent Mamfe basin. The wide spread of igneous intrusions in the Flank suggest that the Flank must have been subjected to high temperature. This is likely the source of the thermal remanent magnetization in the Flank. Igneous rocks could be associated with thermal remanent magnetization (TRM). This is a very stable magnetization which can remain unchanged for a long intervals of geological time (Lowrie, 1997).

Analyses of the 2 data sets (Fig. 6 and 7) show that there are magnetic lows in the north flanked by highs in the south. The interpretations are reflected in Fig. 9 and 10 and the resulting interpretation gives β = 1.00 and therefore, θ = 90° and I_e = 10.9°. Thus, the resolved direction of remanent component of magnetization (I_r) is 260°/-100°. The most probable source of this remanence is detrital remanent magnetization due to the great thickness of sedimentation in the Niger delta basin of Nigeria. This supposition is not out of place because during sedimentation viscosity is usually low in the water column and therefore, there is a strong tendency for magnetic grains to become aligned with the magnetic field in response to the magnetic torque. In addition, interaction among forces arising from turbulent motion of the water and agitation of the grains themselves may result in the net alignment of magnetic grains in the direction of the existing field (Tauxe, 2003). This approach of interpreting detrital remanence from magnetic data is instructive because the problem of inclination error (where the tangent of the observed inclination is usually some fraction of the tangent of the applied field) during laboratory analysis (Tauxe, 2003) does not arise.

CONCLUSION

A method of determining remanence of magnetic source from magnetic data in magnetic equator has been presented in this paper. The basic idea is that if the remanent magnetic field is recognized in a magnetic data and the resolved direction of the remanent component of magnetization is evaluated quantitatively, it will serve as a basis for paleomagnmetic study.

A dyke like model is assumed in this investigation because of its suitability in most subsurface geological situations. The method is however more amenable to interpretation when anomaly minimum and maximum are well developed. The technique is less time consuming, simple, cheap and can equip geomagnetisians with basic fundamentals for paleomagnetic studies in magnetic equator.

The technique has been applied to data from the Niger Delta basin of Nigeria and its environs (Calabar Flank). Analysis of the data sets show that the remanence offshore Niger Delta basin is likely to be due to detrital remanent magnetization while in the adjacent geological province (Calabar Flank) it is due to thermal remanent magnetization owing to intrusive bodies. The resolved directions of remanent component of magnetization obtained from the case studies are useful for paleomagnetic study of rocks in the area.

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