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A TECTONIC INTERPRETATION OF A LINEAR MAGNETIC ANOMALY OVER CHIBOK, NE NIGERIA

N. E. BASSEY

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ABSTRACT

This work attempts to interpret a linear NE-SW (N60^{O}E) trending magnetic anomaly over Chibok, Hawal Basement Complex, NE Nigeria. The said anomaly extends through a distance of over 20 km with a horizontal gradient of 300 γ/km. Field geological mapping shows a granitic terrain deformed by shearing, faulting and jointing of rocks. NW-SE, NE-SW, N-S shear directions are found in the area. 2-D modeling of the magnetic anomaly gave a depth to the causative body of 2.65km. Evidences from satellite data, physiography and field structural mapping show that Chibok area shares geostructural similarities with fault/shear zones of Kaltungo and Wuyo-Gubdrunde inliers of the Upper Benue Trough. Based on this it is posited that Chibok linear magnetic anomaly is an extension of major Benue Trough fracture zones invariably oceanic fracture zones into Hawal basement. The possibility of uranium occurrence in the area is presented.

KEYWORDS: Lineaments, fault, shear zone, horst and graben.

INTRODUCTION

Chibok is a town located towards the northern boundary of Nigeria's NE Precambrian basement region (Fig.1), which is also called Hawal Basement Complex. On sheet 134 of the aeromagnetic map of Nigeria published by Geological Survey of Nigeria (1975) is a remarkable NE trending linear magnetic (low) anomaly over Chibok. The anomaly extends for more than 20 km, with a width through its centre of about 6 km (Fig.2). Interest on the cause/implication of this anomaly was aroused in the course of doing a structural study of Hawal Basement Complex as part of a doctoral work in geology.

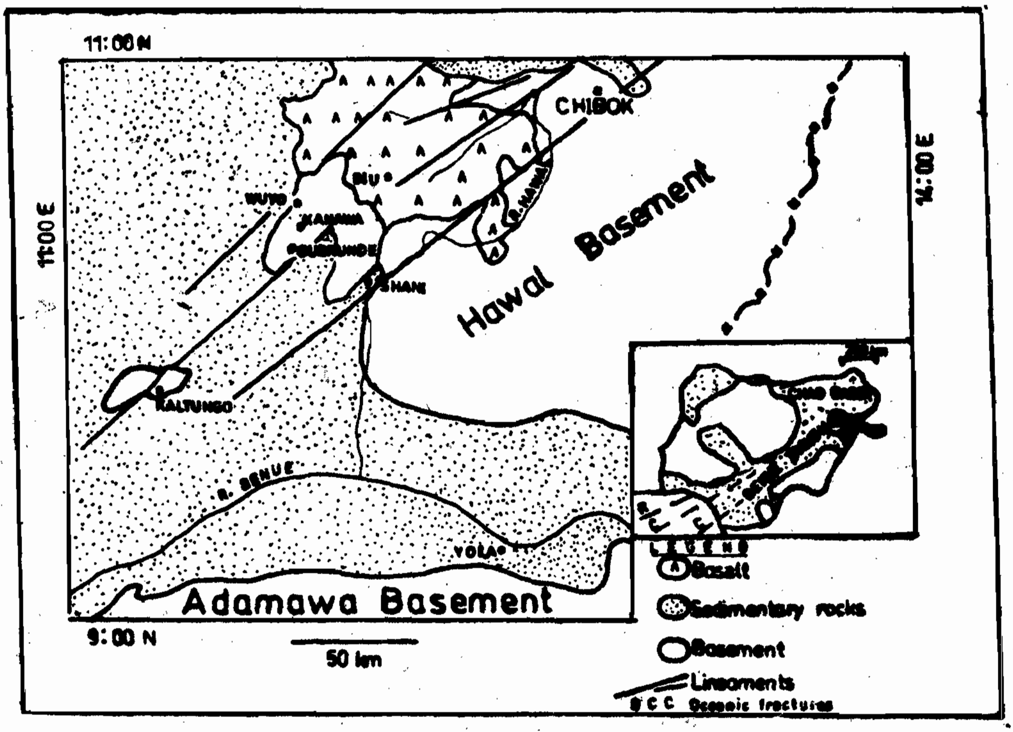

Fig. 1 Top: Generalized geological map showing study area, and some lineaments in part of Upper Benue Trough and Hawal Basement. Inset : generalized geological map of Nigeria. [Adapted from Maurin et al. (1986), Geological survey of Nigeria (GSN) (1994), Bassey et al (2000).

N. E. Bassey, , Department of Geology, Federal University of Technology, P. M. B. 2076 Yola - Nigeria.

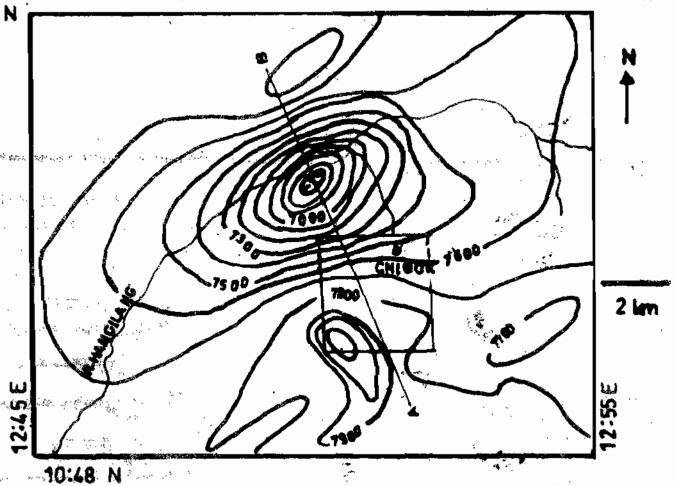

Fig. 2 Bottom: Magnetic anomaly map of Chibok, (reproduced from GSN series (1975). Add 25,000 gammas to get absolute contour values. [Area in box is site of ground geological mapping]

The area of present study lies between longitudes 12:45 and 12:55E and latitudes 10:48 and 10:56N (Fig.2). The existence of the said magnetic anomaly has not been reported elsewhere in the literature, and in this paper an attempts is made to interpret the Chibok magnetic anomaly in the light of available geological information over the area and the adjoining regions. The anomaly is here interpreted in terms of tectonic shear/fault zone, an extension of oceanic fracture zone through the Benue Trough into the basement of NE Nigeria.

STRUCTURE OF CHIBOK

The area where field geological investigation was done is the only site with mappable rock outcrops at Chibok. It consists of a group of granitic inselbergs surrounded by thick elluvial materials being weathered product of a presumably metamorphic basement (Fig.3). Bassey (2005) gave details of the geology and structure of Chibok. The area has granitic rocks of generally medium grain in texture, whose colour is determined by the dominant feldspar content. We have whitish and pinkish varieties. Major constituent minerals of the

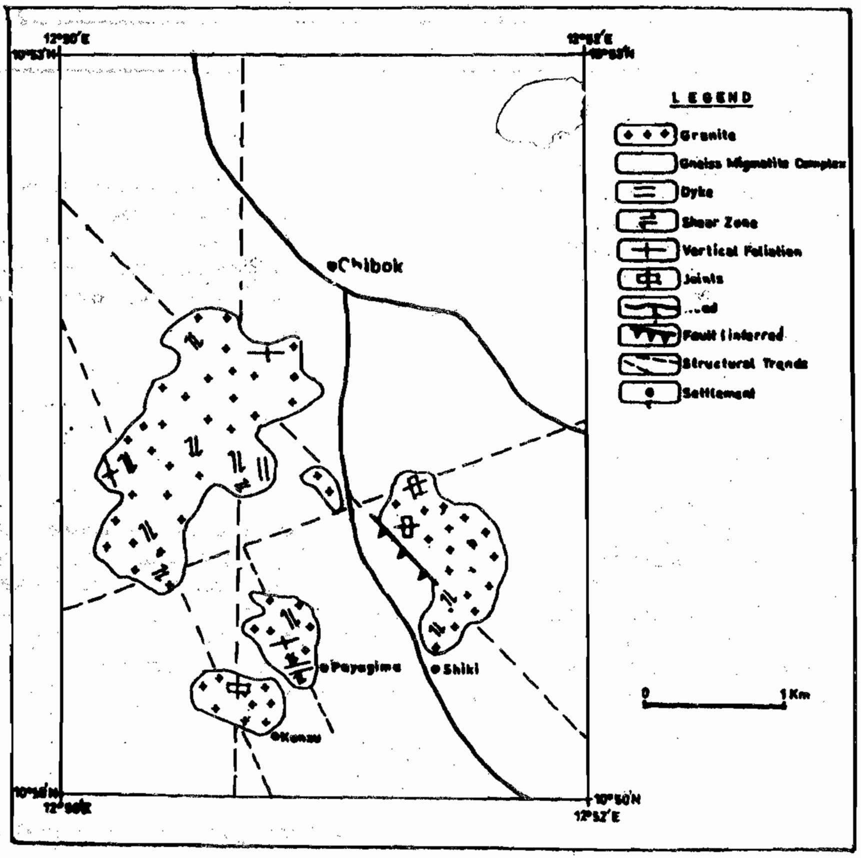

Fig. 3 Geological map of Chibok

granites are quarts, feldspar, muscovite and biotite. Foliation on the rock is generally weak and vertical. Shear deformation is the commonest structural feature, with many of the shear zones develop into faults and joints. About 87 shear zones were observed and their strikes measured. The rose diagram of the shear zones is presented in Fig. 4a. The major shear directions from the measurements are NW-SE, N-S and E-W. The apparent minor nature of NE-SW shear deformation from the field data could be explained by the limited area the field mapping covered. Pegmatite dykes and veins, and microgranitic dykes occur as intrusive in the granites. Their emplacements seems to be controlled by shear fractures (see: Fig. 4b). The shear zones intersect one another in the field producing rock breccia (Fig. 5A). Tectonic joints are common on the eastern and southern hills and their influence on the geomorphologic evolution of the hills is profound (Fig. 5B).

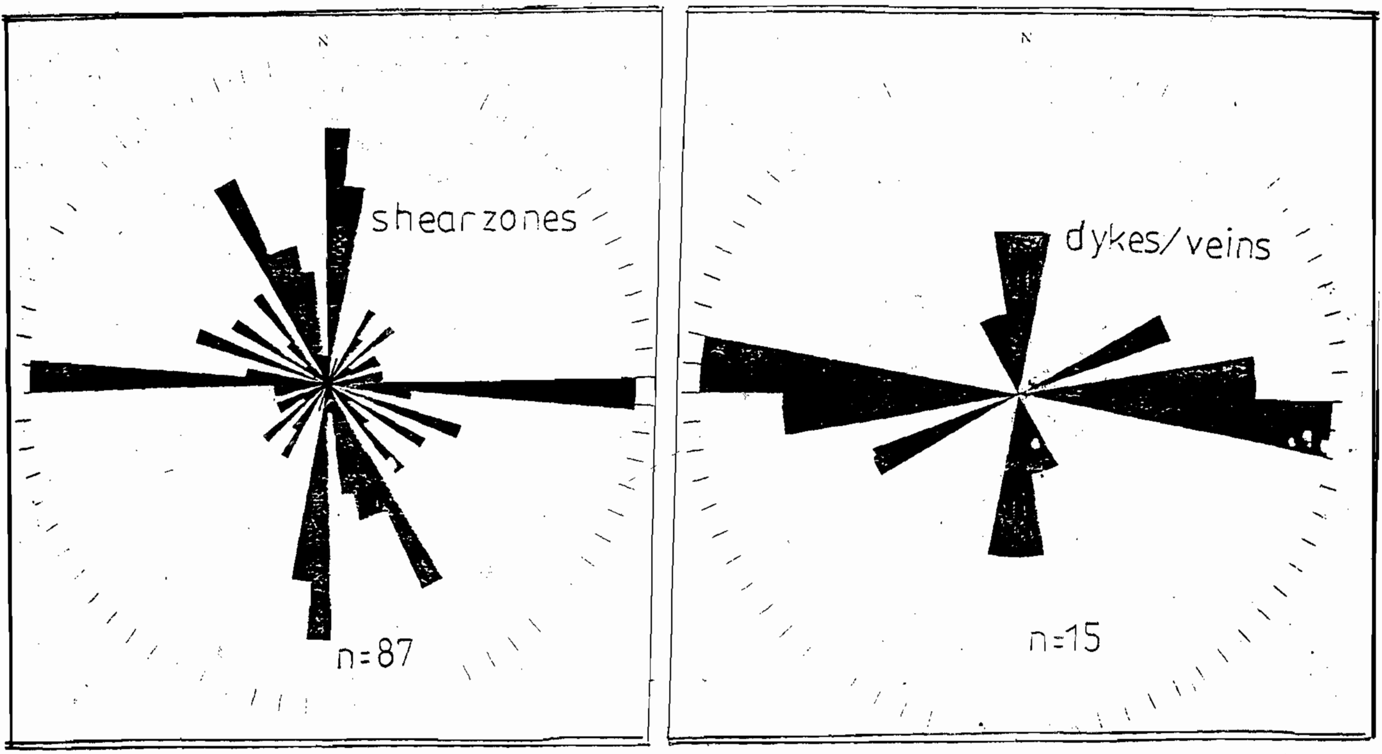

Fig. 4 Rose plots showing trends and distribution of structures in Chibok area.

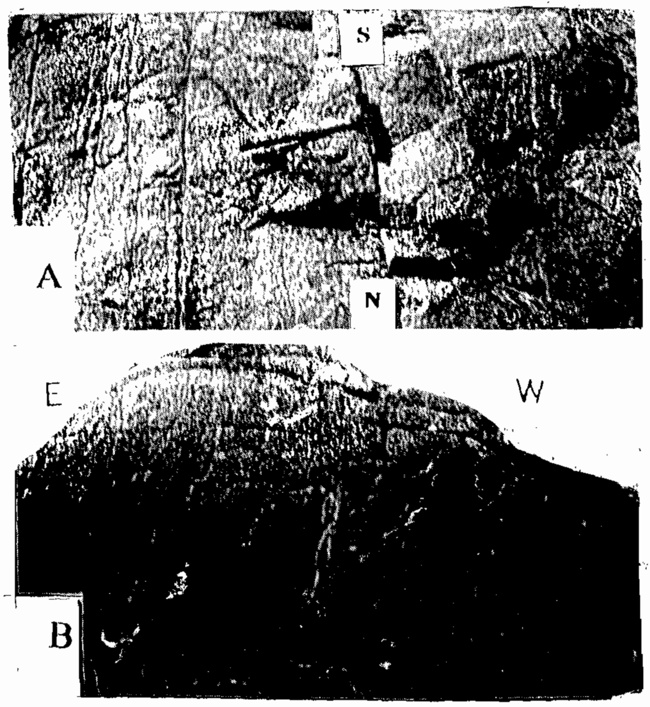

Fig. 5 Field photographs (A): shear zones in Chibok (notice N-S, NW-SE and NE-SW shear deformations). B: Tectonic joints on a hill largely shaped by the joints.

MAGNETIC ANOMALY

The interpretation of a magnetic anomaly pattern on a magnetic map in terms of rocks must be made in conjunction with available field geological observations. Conversely the availability of a magnetic map is of great value in constructing the geology in an area of sparse rock outcrop such as the present study area. The magnetic anomaly analysed here covers an area approximately 214 km^2 (Fig.2). The anomaly is in two parts namely a major (linear) part, and a minor part found to the south of the major anomaly. The minor anomaly consists of a NE-SW trending portion with a length of about 8 km, upon which is superimposed a northwesterly anomaly with a southwest arm. The trends of the major and minor anomalies are in accordance with the NE-SW and NW-SE tectonic trends deduced from the geological map (Fig. 3). The major magnetic anomaly is a low (depression) with a high gradient about 300 gammas per kilometer. A river (R. Hangilang) flows southwestward through its centre. This indicates that the anomaly is over an area of topographic depression (valley). A magnetic profile A-B and the corresponding topographic profile across the anomaly are presented in Fig. 6a and 6b respectively. Depth estimate to the causative body of the anomaly has been computed across profile A-B using one of the direct interpretational techniques of magnetic data presented by Stanley (1977). This technique is a simplified approach of interpreting magnetic data over a contact structure, and was used by Iliya and Bassey (1993) for depth estimates of magnetic bodies in Oban and Obudu Precambrian basement regions in SE Nigeria. The technique can be used for contact structures such as a fault. The adoption of a contact structure made in this study accords with Parasnis (1986), who said that horizontal anomalies with differing amplitudes are often associated with contacts of rocks of different susceptibilities or unequal intensities of magnetization. Of the contact structure a fault is assumed by reason of similar structures found contiguous to the area of present study at Wuyo-Gubrunde and at Kaltungo (Fig.1), and as reported by Maurin et al. (1986). The calculated depth to the causative body is 2.65 km (see: Fig 6c).

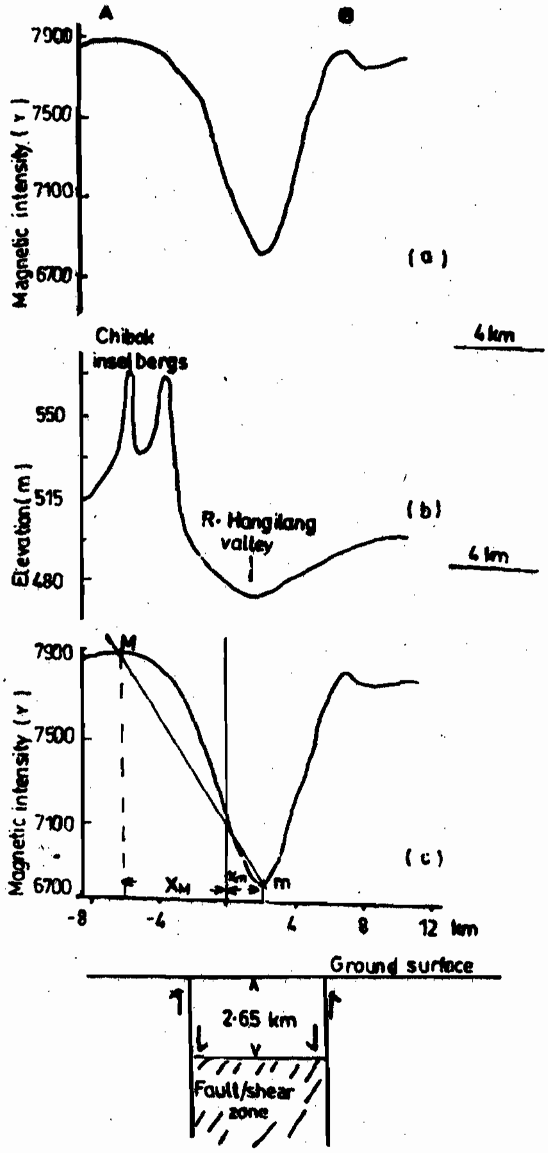

Fig. 6(a) Magnetic profile A-B (from Fig.2) (b) corresponding topographic profile (c) 2-D modeling of magneteic profile for depth estimate using Stanley (1977) model M, m, X_M and X_m are *characteristics* used in compution of depth.

DISCUSSION AND CONCLUSION

The magnetic anomaly over Chibok is attributable to an intrabasement fault/shear zone due to its long wavelength and relatively narrow nature. Parasnis (1986) said that long narrow magnetic anomaly pattern can be caused by shear zones, dykes, long ore bodies or isoclinally folded strata. Under present geological setting (Table 1), it is plausible to attribute the cause of the anomaly to faulting and shearing as there are no evidence presently of the presences of the other features (dykes, long ore bodies or isoclinally folded strata) which should produce the anomaly. Additional evidence that Chibok magnetic lineament is over a fault zone is physiographic. According to Billings (1999) a lineament can be a long depression which is formed by erosion along lines of weakness that may be a fault. River Hangilan must be flowing through a fault zone as the regional tectonic setting shows. It could be inferred that Chibok inselbergs (which rise to about 88 m relative to River Hangilang valley) together with the postulated fault zone constitute a horst-graben system. Hence on a regional scale it is interpreted as a structural continuity of Wuyo-Gubrunde horst-graben system. The continuity is superficially covered by the emplacement of Tertiary Biu Basalt (Fig. 1). From satellite imagery analysis of Hawal basement by Bassey et al. (2000), and Bassey (2005), the Chibok lineaments align along a N50°E direction. This is the trend of Wuyo-Gubrunde lineaments, and the Kaltungo fault zone (Benkhelil, 1986). Bassey (op.cit) observed that the flow trend of River Hawal into Shani sub-basin is along the N50°E direction. This shows a tectonic control of the river, and a further proof of the tectonic relationship between Chibok fault zone and Shani-Wuyo-Gubrunde tectonic region. The N50°E tectonic direction observed in this study is closely related to the N60°E Benue trend of Guiraud (1989).

Shearing, faulting and jointing are other tectonic evidences for the existence of Chibok magnetic anomaly. These features are found over the area covered by the minor anomaly. Susceptibility variations in the granitic rocks could also contribute to the anomaly.

This study has shown that Chibok NE-SW trending lineaments are intrabasement extensions of Benue Trough lineaments traceable to Kaltungo inlier through Wuyo-Gubrunde-Shani fault zones. The long wavelength of the major magnetic anomaly suggests its deep seated origin (Ajakaiye et al., 1991). This is assertion further supported by a computed depth of 2.65 km to the causative body of the anomaly. This depth estimate may not be unique as is generally the case with quantitative results of potential field data. It is however congruent with the result of depth computation to magnetic source bodies over the Benue Trough as given by Ajakaiye et al. (op.cit.). They gave a depth range of 0.4 to 2.6 km. Based on field, satellite and physiographic data it is asserted that Chibok magnetic linear anomaly is produced by a NE-SW trending fault/shear zone which is an extension of the Benue Trough fracture zone into Hawal Basement. It is invariably part of a continental extension of oceanic fracture zones – Romanche, Chain and Charcot fractures, (Benkhelil and Robineau, 1983) which controlled the formation of the Benue Rift. This position agrees with similar inference of Ajakaiye et al (1991). These authors worked on magnetic anomalies in the Nigerian continental mass, and their study area is between longtitude 7:00 and 10:30E, latitude 8:30 and 12:00N. The spatial separation between their study area and that shown in Fig. 1 is only 30 minutes. The authors observed that magnetic lineaments over their study area show up as narrow belts (10-50 km in width) of negative anomalities ranging in length from 10 to 650 km and in amplitude from 150-250 nT. The authors also said that the magnetic lineaments are of sufficient prominence and length to

Table 1: Features of Kaltungo-Wuyo/Gubrunde – Chibok Tectonic Terrains.

Features	Kaltungo Inlier	Wuyo-Gubrunde Horst	Chibok Inselbergs
Geomorphologic features	Basement inlier	Horst- graben system	Hills (horst?) and depression (graben?)
Structural Features	Sinistral wrench fault zone with cataclasites, tectonic breccia, ductile shear zone, presence N-S shear zones.	Presence of faults, and shear zones	Shear zones, faults, tectonic breccia, presence of N-S shear zones.
Structural trend	NE –SW (N50°E) NE –SW/N – S conjugate fractures.	NE – SW (N50°E) dominant direction, others are N-S, and E-W.	Mainly NE-SW, (N50°E) NW-SE, N-S and E – W
Lithologies	Pan African granites	Pan African granites intruded by rhyolites and felsites.	Pan African granites
Mineralization	–	Uranium	Yet to be investigated
	Sources: (Benkhelil, 1987, Guiraud, 1990)	Sources: (Funtua et al., 1992, Suh and Dada, 1997)	

suggest that they are signatures of regional structural features, thus representing major tectonic trends such as deep shear zones that were tectonically active during Precambrian times. They related the magnetic lineaments with Romanche, Chain and Charcot fracture zones.

From similarity of the geological settings of Chibok and Gubrunde areas (see: Table 1), with the latter reported to harbour uranium mineralization by Funtua et al. (1992), Suh and Dada (1997) at Kanawa, it is suggested that a search for uranium could produce positive result at Chibok also. Funtua et al. (op.cit.) reported that uranium mineralized zones are located along N-S trending shear zones at Kanawa. While Suh and Dada (op.cit.) said primary type uranium mineralization are highly localized and confined to zones of brittle-ductile deformation in granitic plutons. Both settings are applicable to Chibok area thus justifying the suggested search. If successful and the deposit are economically exploitable no doubt it would boost national supply especially now that the country is taking steps to generate electrical energy by nuclear means.

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