Interpretation of high resolution aeromagnetic data for mineral prospect in Igbeti-Moro area, Southwestern Nigeria

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Interpretation of high resolution aeromagnetic data for mineral prospect in Igbeti-Moro area, Southwestern Nigeria

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Abstract. High resolution aeromagnetic data that covers Igbeti-Moro area, within southwestern Nigeria, has been subjected to data enhancement processes and interpreted to establish significant geologic features associated with occurrence of marble, gabbro and muscovite mineralization in the area. These were established by applying 2D Fast Fourier transform filters for reduction to equator (RTE), lineament enhancement of vertical and total horizontal gradient, edge detection of analytic signal amplitude (ASA), and magnetic source depth parameter imaging (SPI) and average power spectrum (APS); using Oasis Montaj software. The RTE residual magnetic intensity of the area ranged between - 338.3 nT to - 2.4 nT, 9.9 to 27.7 nT and 32.1 to 208.0 nT for low, intermediate and high magnetic susceptibility respectively which indicate contrasting basement rocks (namely; granite-gneiss) and intrusion of quartz and amphibolite schists. The lineament development and its disjoint revealed fractures and faults associated with emplacement of the quartz-schist and muscovite-schist, which would have formed synchronously with isoclinal fold and hosts marble, gabbro, amphibolites and muscovite mineralogy at shallow depth that ranges from 0 to 200 m in the northeastern, western, north central sections of the area. The geologic features observed in the study area have been established to be associated with the solid minerals that can be of social-economic benefit.
Keywords: geologic features, lineament, Fast Fourier transform, magnetic anomalies, Mineralization

1. Introduction
Minerals are key element to nations building and require several methods to recognise its areas of deposit. The deposition of these minerals can be in tabular or shell-like form, filling a fracture in a host rock controlled by hydraulic of magmatic water that carries large amount of dissolved minerals which it deposits in veins as it travels to the earth surface [19];[9]. However, minerals are not easily determined except with the expertise of geologists and application of geophysical tools. Geophysical method such as aeromagnetic data has been chiefly used for geologic structural mapping and mineral exploration [10];[15]. The elementary geophysical understanding behind this is that; different rock types host different magnetic responses and as a result several analytical data processing tools is needed to enhance the output images of these magnetic responses for better geologic interpretation. Among the filtering and analytical tools employed are upward and downward continuations, vertical derivative (VDR), total horizontal derivative (THDR), analytic signal, tilt (TDR) and theta derivatives etc. These tools reveal the variation in magnetic susceptibility of the basement and that of the

overlying sediments [8];[1]. In this present study, airborne magnetic technique has been used to delineate geologic features that are associated with solid minerals in part of Igbeti-Moro area, Southwestern Nigeria.

1.1. Description and geological settings

The study area is located between Oyo and Kwara, Southwestern Nigeria and within about 3064 square kilometer between longitudes 4°00′ E to 4°30′ E and latitudes 8°30′ N to 9°00′ N. It covers Igbeti (northern part of Oyo State) and Moro (southeastern Kwara State) in Southwestern Nigeria and it is traversed by a major road linking the south-western part to northern regions of Nigeria. The climate of the study area is characterised by both the wet and dry seasons. The rainy season begin in late March and end in October, while the dry season begin in November and end in early March. The natural vegetation is guinea savanna characterized with scanty forest or averagely thick forest mainly along the stream's path. Its major lithological units are of the precambrian basement complex of Nigeria [14] comprising the older granite series, metasediments and migmatitic gnesis complex (Fig. 1).

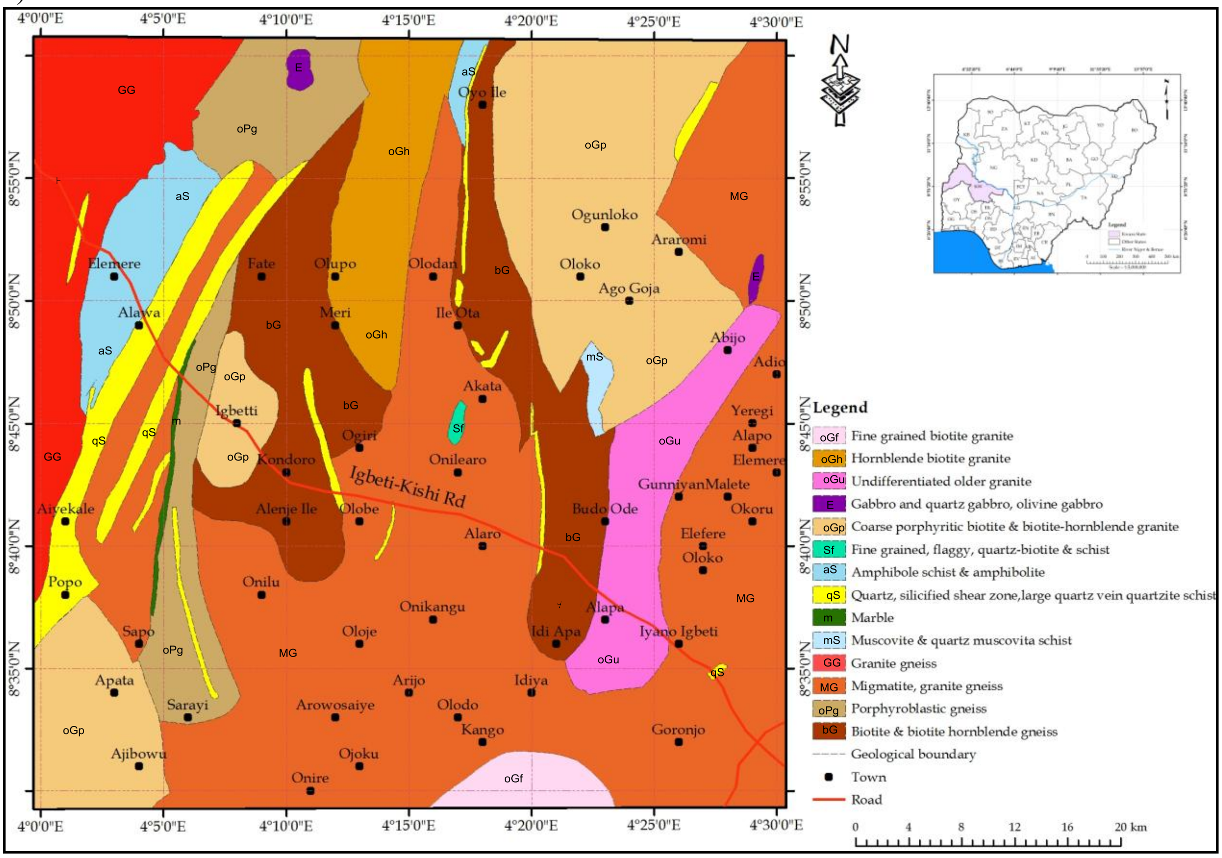

Figure 1 Location and Geological Map of the Study Area (After [13])

2. Data acquisition and processing

The aeromagnetic data was acquired from Nigeria Geological Survey Agency (NGSA), as part of the data set of total field magnetic intensity obtained during airborne geophysical survey of Nigeria within 2003 and 2009 by Fugro Survey Limited. The survey was aimed at promoting mineral exploration in Nigeria [12]. Igbeti-Moro has been designated as sheet 201of the gridded aeromagnetic data of Nigeria. It was de-cultured, leveled and corrected for international Geomagnetic Reference Field (IGRF). The grid enhanced anomaly details and reduced possible noise and latitude effects [18].

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2.1. Data reduction and processing
In mineral exploration, to infer meaningful interpretation from aeromagnetic data, processing and reduction of potential field are essential tools [24]. In this study, the data was filtered using the fast Fourier transform, conversion of data from one form to another by reducing the data to magnetic equator (RTE) and producing residual magnetic intensity map. Edges of magnetic source body were enhanced by vertical (VDR) and total horizontal derivatives (THDR) while depth to magnetic sources estimate using source parameter imaging (SPI) and average power spectrum. Data processing and reduction methods are most effective when dealing with shallow source depths and rock types with relatively large contrasts in magnetization [3]. The asymmetric and lateral shift of measured magnetic total field (Fig. 2a) was corrected by applying RTE and the resultant residual anomaly map (Fig. 2b) showed magnetic responses of rock masses or mineral deposits, their shapes and magnitude, the direction and strength of its magnetization with respect to their global location. The rate of change of magnetic field spatially in vertical and horizontal directions is quantified with their derivatives [21] by enhancing local anomalies obscured by broader regional trends. THDR is related to vertical derivative (VDR) by mathematical expression in Equation 1[17] and its map (Fig. 3) delineated limits of intrusive bodies, faults and other lateral changes [11].

$$Tilt\ derivative\ (\theta) = \tan^{-1}\left(\frac{VDR}{THDR}\right) \qquad \text{Eqn. 1}$$

The SPI submenu of Oasis montaj's geo-software was applied for an automatic location and depth determination of causative bodies from the gridded magnetic data using the local wavenumber of analytic signal [20];[23].

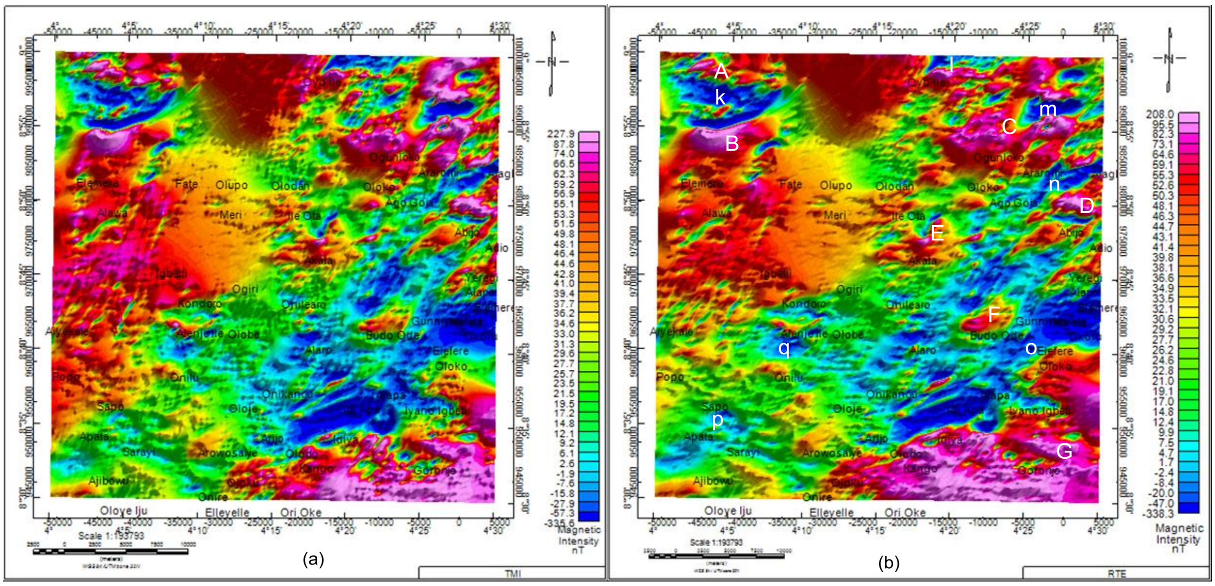

Figure 2 Comparison of (a) the total magnetic intensity and (b) the Reduced to Equator Residual Magnetic Intensity maps.

3. Results and Discussion
The RTE map show no significant modification of the original magnetic anomalies on total magnetic intensity (TMI) map (Figure 2a), marked as positive and negative anomalies A, B, C, D, E, F, G, and k, l, m, n, o, p, q, r respectively. The amplitude of anomalies range from – 338.3 nT to 208.0 nT (Figure 2b) which were consistent in pattern, trend and amplitude of the total magnetic anomalies within – 335.6 nT to 227.7 nT shows that the data has been well filtered. The southeast and northwestern regions of the RTE map is characterized by positive (high) magnetic intensity value range between 32.1 nT to 208.0 nT, the west and north – north central regions host intermediate

magnetic value range within 9.9 to 27.7 nT while the northeast to east, central and southwestern regions have negative anomalies range between - 338.3 nT to - 2.4 nT. The THDR map defined the edge of these lithologic bodies and linear features with low anomaly gradient within -1.47 and 0.04 nT/m.

3.1. Lithologic mapping

4.

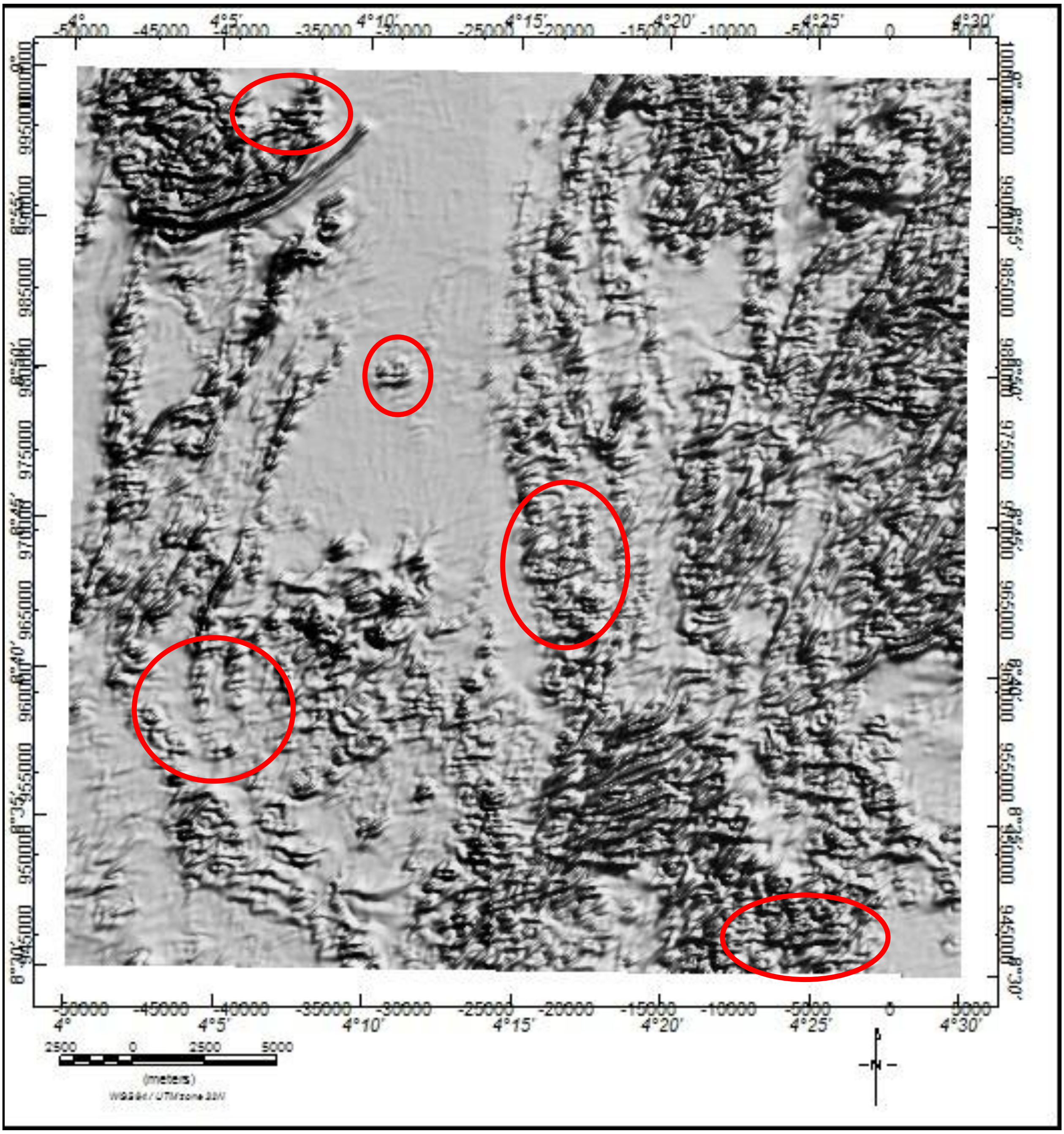

Figure 3 Total horizontal Derivative map

Careful examination of the RTE map (Fig. 2b) with the geological map (Fig. 1) showed that the alternating positive and negative magnetic values suggest rock contrast in the basement of the study area. The intermediate magnetic anomalies are connected with intrusion of quartz and amphibolite schists bounded by relatively low magnetic intensity; which is associated with older granitoids [2]. The negative anomalies are associated with mining and prospecting areas for minerals [4];[16] like the marble, gabbro, amphibolites and muscovite mineralogy within the granite-gneisses in the west and north – north central regions, which commonly carry small amounts of magnetite and dark minerals like biotite and hornblende (paramagnetic). The minerals have possibly been deposited in the quartz vein [5];[6] or have resulted from the intrusion of hydrothermal fliuds which can deposit less magnetic materials in the fractured rock [7]. The positive magnetic anomalies amplitude is allied with gneiss complex rocks namely; granite gneiss, migmatite gneiss and biotite gneiss which makes the various lithologic units in the area [22].

The SPI map (Fig. 4) showed shallow to deeper magnetic source depth range of - 335.6 to 227.9 m. The region of extreme topography coincide notable hills that stands around 330 m above the country rocks in the north-northwest, sparingly in southwest and southeastern parts. These showed that the host rock is more magnetic than the intrusive rocks and can be due to reversed remanent magnetization [5] or associated with weakly magnetic rocks. The area of revealed mineralogy banding falls within shallow mineral exploration depth range classification of [6].

4.1. Structural mapping

The THDR map (Figure 3) revealed prominent NE – SW structural trend which is in concordance with the generally known deformation trend (Kibarian orogeny) in the basement complex rock of Nigeria. The scanty east – west lineaments in concordance with the east – west magnetic anomalies (Fig. 2b) enclosed in red oval (Fig. 3) indicate ductile deformation which could exhibit structural features such as faults and fractures. The faults indicate the emplacement of quartz-schist and muscovite-schist which host the marble, gabbro, amphibolites and muscovite mineralogy in the eastern, western and north central parts of the study area.

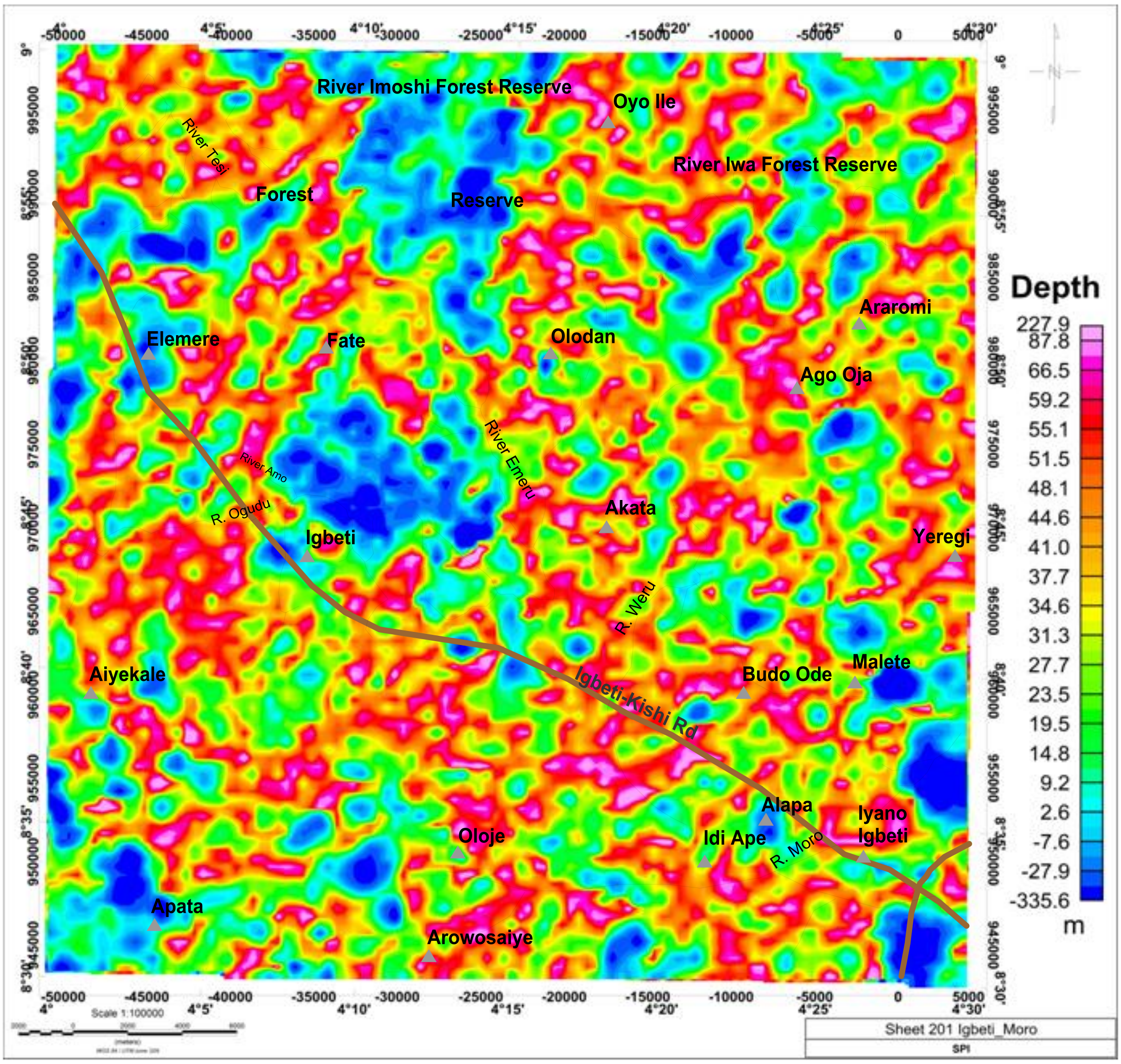

Figure 4 Source Parameter Imaging depth estimate maps

5. Conclusion

High resolution aeromagnetic data of Igbeti-Moro has been processed, enhanced and analysed using Oasis Montaj geo-software in order to map geologic structures related to mineral exploration in the area. From the results of interpretation, lithological boundaries and contacts, intersection of geological structures, faults and magnetic sources depths were established. The negative anomalies of the reduced-to-equator residual magnetic intensity indicated the marble, gabbro, amphibolites and muscovite mineralogy which are distributed within the western, northern and northeastern parts of the study area and bounded by positive anomalies associated with gneiss and older granitoids; which formed the major lithologic unit of the area. The minerals exist at shallow depth range of 0 – 200 m and have possibly been deposited by intrusion of hydrothermal fluids along quartz schist veins during the deformation that led to the formation of resultant faults. The pattern of occurrence and associated geologic structures showed that the minerals deposits in the study area are structurally controlled; which is critical in mining operation.

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