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Mapping of Lineament Structures from Aeromagnetic and Landsat Data Over Ankpa Area of Lower Benue Trough, Nigeria

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Abstract

Structural analysis of aeromagnetic and Landsat data over Ankpa area, Benue state was carried out to delineate the basement topography, hydrocarbon potentials, groundwater availability and the structures that control basin formation. The Landsat imagery generated from this study was further processed using Geomatica software (version 9.0). The results obtained revealed that the drainage pattern is dendritic which could be associated to the lithological, structural and topographic differences. Also, this may indicate the presence of alluvial rocks, typically of the same geology, mainly of sedimentary rocks. This present study is in good agreement with the areas in the lineament map of high-density structures. The observation showed that the study area constitutes densely lineaments that cut across each other, which may be attributed to groundwater availability and upward migration of hydrocarbon-bearing formation. The structural trend is predominantly in the NE-SW direction and agrees with the Landsat data structural trends. Significantly, this NE-SW trend is in agreement with the trend of Benue Trough (NE –SW) and could be that they have the same structural control.

Keywords: lineament; Landsat; basement depth; Lower Benue Trough; drainage; aeromagnetic
PACS: 91.25.Qi; 43.40.ph; 93.85.-q; 07.88.+B

1 Introduction

The source and transformation of the Benue Trough are adequately reported [5, 6, 8, 19, 21, 27]. They include the intersection of major lineaments or combination of both minor and major, local lineaments and tracing of extensive geographical lineaments. Features that are linear are clearly observable on aeromagnetic maps, which often-times signify the position and form of joints, lithologic, faults and distinct geologic attribute leading to the mineral deposits location [2], The use of remotely-sense data for hydrogeological studies is becoming well known most especially area where traditional method such as electrical resistivity technique is inadequate. The past application includes the work of [4, 9, 11, 16]. Recently, there has been a successful joint application of remotely sensed data as a complementary technique with other conventional methods for hydrogeophysical studies [1, 12]. There is still no single method of giving a unique solution for estimating the depth parameter because of the inherent ambiguity due to different subsurface sources. In this paper, we study the variation in depth estimation due to a single known source from two different measured components of the geomagnetic field. At some time-independent magnetic variations are established; which has been well known from adjoining effects, and this appearance may be a single magnetised body. The size and shape of this magnetic formation can be detected most effectively using quantitative methods. The depth framework, which is the most significant use of magnetic data [23] permits mapping of the topography and surface of basement rocks, likewise the sedimentary cover thickness [7]. This study aimed at integrating the aeromagnetic method and Landsat imagery to identify the subsurface structure that controls the groundwater system as well as the features that could be trapped for hydrocarbon-bearing formation.

2 Geology of the Study Area

The study area is located within the Lower Benue Trough and lies within latitudes 7°10’ N- 7°32N’ and longitudes 7°24’ E- 7°46’ E (Figure 1). The geology of Ankpa is the

geology of the Lower Benue Trough. The Benue Trough in Nigeria is a NE-SW trending sedimentary basin portioned geographically into Lower, Middle, and Upper Benue Troughthat extends for about 1000km in length with width ranging from 180km to 250 [26].

Figure 1

Geological map of the study area

3 Theory and Methods

Both Landsat and magnetic data share common features which serve as an interface for interpreting geological attribute which can be noted in between the features. Extensively, Landsat and magnetic data have been used as tools for reconnaissance survey in minerals and oil probe. In a similar vein, both have discontinuities at the surface noticed by the resemblance of the linear anomalies to surface faulting as evidence across the area.

Polynomial fitting is an entirely analytical technique that involves conjoins of the regional by a polynomial surface of low order which exposes the residual attribute as random errors. The system is based on statistical theory. In practice, the polynomial is rarely extended beyond the second order. An unswerving line usually typifies the regional field or generally, by a smooth polynomial curve. The least square technique is always used for the polynomial fitting. But, it should be well noted that this method has its inherent drawbacks which are:

1. Better fitting observations require a higher order of polynomials.
2. The unreasonable order of the polynomial is less than the number of the observations through which the curve passes wholly through all the data points but geologically has no meaning.

Other analytical methods used include 2-D spectral analysis. The use of spectral analysis in interpreting potential field data is one of the techniques that can be used to estimate the depth to the magnetic source which has been effectively well established [22]. Various researchers have used the method in the evaluation of the sedimentary thickness of basins around the world [18, 20, 24].

The derivation of power spectrum from the 2-dimensional set of data namely Bouguer gravity data has a 2-dimensional form. For easy interpretation, the mean of azimuthal of the 2-dimensional power spectrum is estimated to generate a simple 1-dimensional output as represented in Figure 2. Occasionally the power spectrum may be grouped into 2 or more unswerving line segments. The inclination of each segment can be interconnected to the depth of group of anomalous origins which are in the range of spatial frequencies as defined by the segment.

Figure 2

Showing a one-dimensional output of a power spectrum

3.1 Materials and Methods

The aeromagnetic map of Ankpa was obtained from the Nigerian Geological Survey Agency (NGSA). The half-degree sheet data (7°00 – 7°30 N and 7°30 – 8°00 E) and in the scale of 1:100000,were acquired at a flight altitude of 80 m, along NE-SW flight lines that were spaced at 500 m. The spatial variation effect in the geomagnetic field caused by the geomagnetic field derived from the outer core of the earth was removed [16]. The total magnetic field intensity range between 32350 and 66900 nT (see Figure 3). Most of the anomalies trend NE–SW, but some most especially at the southern segment of the map, trend E-W. A very high magnetic intensity was observed between latitude 7°00 – 7°2.4N, and longitude 7°30’ – 7°36E (Figure 3).