Pacific International Journal, Vol. 3(1), 29-32; 2020
ISSN (Print) 2663-8991, ISSN (Online) 2616-4825
DOI: 10.55014/pij.v3i1.93
https://rclss.com/index.php/pij

Qualitative Evaluation of Geophysical Aeromagnetic Data for River Anticline Around The River Niger Area In Koton-Karfi, Southern Bida Basin, Nigeria

Nwofor, Victor Udokamma[1], Charles Ugwu Ugwueze[2], Njoku, Ikechukwu Onyema[1], Jack Leah[1], Choko Chukwuemeka[3], Ibeneme Sabinus Ikechukwu[1]

1Department of Geology, Faculty of Physical Sciences, Federal University of Technology, Owerri, Imo State, Nigeria.
2Department of Geology, Faculty of Sciences, University of Port Harcourt, Choba, Port Harcourt, Rivers State, Nigeria.
3Department of Physics, Faculty of Sciences, University of Port Harcourt, Choba, Port Harcourt, Rivers State, Nigeria.
*Correspondence: victorudokammanwofor@gmail.com

In this paper a qualitative evaluation of aeromagnetic data maps has been used to preliminarily support the formation of river anticlines beneath major rivers due to isostatic rebound as a result of deep river incision of surface and sub-surface overlying rocks. The regional gradients of digital high resolution aeromagnetic data were removed by polynomial fitting. This involved fitting a plane surface to the reduction to pole map of the aeromagnetic data by using multi-regression least square analysis of the Oasis Montaj 6.4 program. The regional field values from the plane surface are subtracted from the observed data to obtain the residual anomaly values. Power spectrum plots of aeromagnetic data of the study area produced a basement depth contour map. The basement depths of the south-western part of the study area revealed basement uplift with a depth range of 1.8 to 2.5km which lies beneath the Niger River area, SW of the study area and depicts a river anticline.
Keywords: Isostatic rebound, Spectral analysis, River anticline, Koton-Karfi, Bida Basin, Aeromagnetic data

Introduction

Isostatic rebound has been used to explain the formation of the river anticlines structures that run parallel to high erosive rivers where crustal strength is relatively low (Montgomery and Stolar, 2006). The Himalayan and the Andes rivers are examples of known rivers that have river anticlines (Robl et al., 2008). A river anticline is a geologic structure that is formed by the focused uplift of rock caused by high erosion rates from large rivers (Montgomery and Stolar, 2006). Rivers anticlines formed by Isostatic rebound are similar to those formed in post-glacial rebound. Crustal rebound is the rise of land masses after the lifting of the high weight of surface and sub-surface sediments. In the case of the river anticline formation, large weight of sub-surface to surface sediments were remove by the incision of the then youthful rivers. The isostatic rebound has gotten a wide acceptance after it was used to explain the orogeny of the Himalayan where the Indian continental plate is crashed into the Eurasian continental plate (Burbank and Bullen, 1999). The North-South motion of the converging plates infers that the trending of the river anticlines should be in the East-West direction. It was observed that the folding occurred in the North-South direction. The explanation of the orientation of the fold for decades was an assumption that these rivers did not form the anticlines instead the parallel direction of the river course and the fold axis of the river anticline was a coincidence (Burbank and Bullen, 1999). The information of the river anticline around large highly erosive rivers where crustal strength is relatively low became more prevalent in the geomorphology of river courses, that there arouse the need for a scientific explanation rather than a speculation. The idea of isostatic rebound was inferred and over recent years has become the best fit mechanism of high acceptance.

In this research, a segments of the Niger River, the largest river of West Africa, found in Konto-Karfi sheet was considered alongside the qualitative evaluation of the geophysical first order residual aeromagnetic map and the basement contour map derived from spectral analysis to preliminarily support the formation of river anticline beneath and parallel to major river courses due to crustal rebound.

Geology of the study area:

According to Obaje et al. (2011), the Bida Basin, also known as the Mid-Niger or Nupe Basin, is located in west-central Nigeria. The Bida basin is a NW-SE trending intracratonic structure extending from kontogora in Niger State to Kogi State – slightly beyond Lokoja. The basin is bound in the NE and SW by the basement complex and in the SE and NW by the Anambra and Sokoto basins respectively (Figure 1). Bida Basin is a gently down-warped trough whose origin is closely

[Received 02 Dec 2019; Accepted 13 Feb 2020; Published (online) 31 Dec 2020]
Publisher's Note: RCLSS stays neutral regard to jurisdictional claims published maps

connected with the Santonianorogenic movement in southeastern Nigeria and the Benue valley, with its sedimentary fill comprising of post-orogeny molasses and thin unfolded marine sediments (Ladipo, 1988). The basin trends in the NW-SE direction, a NW extension of the Anambra Basin perpendicular to the main axis of the Benue Trough.Koton-Karfi and enviros fall within the southern Bida Basin stratigraphically comprises of the basal CampanianLokoja Formation, followed by the Maastrichtian Patti Formation and then the Agbaji Formation which is also Maastrichtian in age.

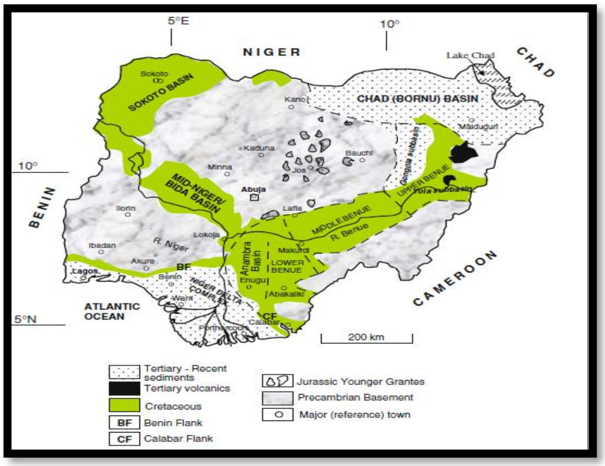

Figure 1: Geologic map of Nigeria (Obaje et al., 2004)

Gravity studies in the Bida Basin put the maximum thickness of the sedimentary sediments at about 3.5 km in the central axis (Ojo, 1984), but a recent spectral analysis of the residual total magnetic field in different sections of the basin showed an average sedimentary fill of about 3.4 km with basement depth of up to 4.7 km in the southern and central parts of the basin (Udensi and Osazuwa, 2004). In general, the depth to basement in the basin decreases smoothly from the centre to the flanks of the basin.

Data:

Digitized high revolution aeromagnetic maps of sheets 206, 207, 227, and 228 of the scale of 1:100,000 covering a total area of about 12,000 km^2 were used in this study with the following towns inclusive: Gulu, Koton-Karfi, Abaji, and Kuje. The maps were acquired, analysed, and interpreted using several potential field softwares which include Oasis Montaj 7.2HJ version. Fugro Airborne survey from 2006 to 2009 obtained the maps for the Nigerian Geology Survey Agency. The aeromagnetic survey was flown along a series of NW-SE flight lines spaced at 500 m (perpendicular to dominant regional geologic strike) with 2000 m tie line spacing in the NE – SW direction. Data were recorded at very small intervals of 0.1s each with 80 m normal flight height. The geomagnetic gradient was removed from the data using January 2005 IGRF model referenced to the World Geodetic System, 1984 ellipsoid.

Theories and methods:

Isostatic Rebound is also known as crustal rebound. It is the rise of the land masses after the lifting of the huge weight of ice sheets during the last glacial period, which had caused isostatic depression (Milne and Shennan, 2013). It is the deformation of the earth crust in response to changes in ice mass distribution. This theory can also be used to explain the earth crust deformation by focused uplift of rocks caused by high erosion as huge weight of surface and sub-surface sediments were removed by the incision of the river course.

Total magnetic intensity (TMI) of the aeromagnetic data of the study area shown in figure 2 was filtered digitally by the use of non-linear filters to eliminate certain wavelengths. The filtered TMI data was further reduced to the magnetic pole as shown in figure 3. Reduction to pole (RTP) transformation was applied to minimize polarity effects. The reduction to the pole is a filtering technique used to assign the peaks and gradient of the magnetic anomalies directly over their sources (Ahmed et al., 2013).

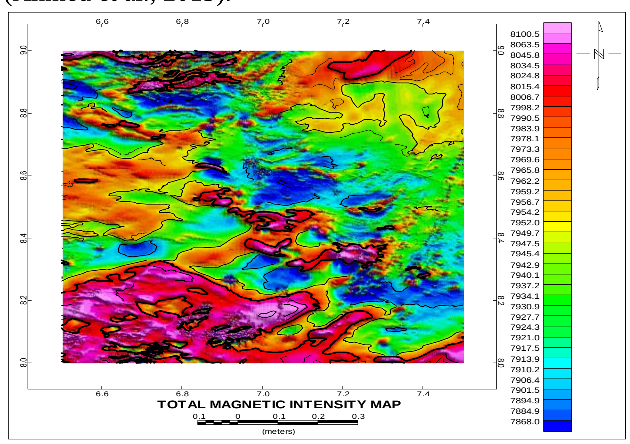

Figure 2: Total Magnetic Intensity Map of the Study Area

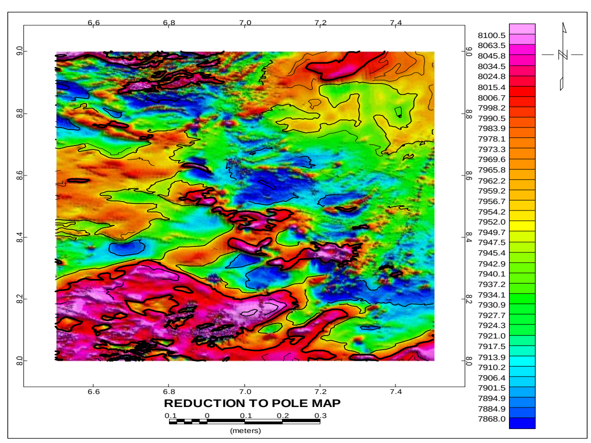

Figure 3: Reduction to Pole Map of the Aeromagnetic Data

The regional gradients of the high resolution aeromagnetic data were removed by polynomial fitting. This involved fitting a plane surface to the aeromagnetic data by using multi-regression least square analysis of the Oasis Montaj 6.4 program. The regional field values from the plane surface are subtracted from the observed data to obtain the residual anomaly values. The technique was carried out on the high resolution aeromagnetic data of the study area to produce the regional and residual field maps shown in figures 4 and 5 respectively.

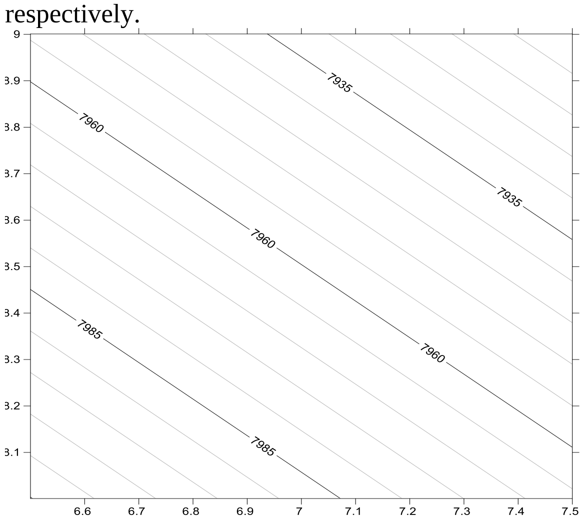

Figure 4: Regional field map of the study area.

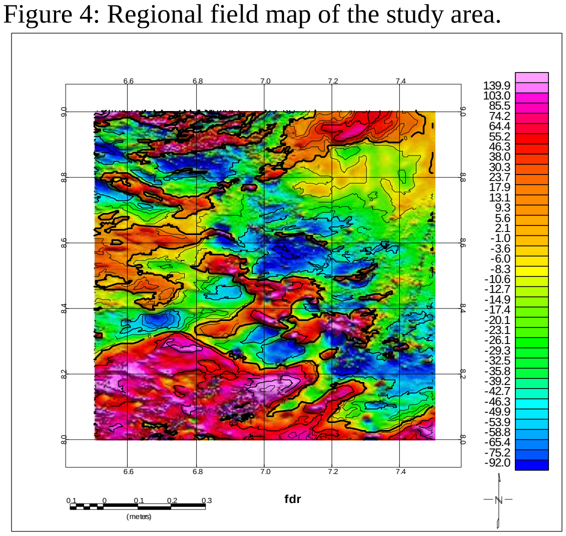

Figure 5: First degree residual field map of the study area.

Spectral Analysis was carried out on the residual map of the study area to infer the magnetic basement depths. The spectral analysis method was well established by Spector and Grant, 1970. They showed that when a statistical population of a potential field source exists at around a specific source depth, then the expression of those sources on a plot of the natural logarithm of energy against wave number is a straight line having a slope of - 4πh (Reeves, 2005). If a spectrum has a number of straight lines branches, statistical populations of sources exist at such number of depths (Reeves, 2005). Mathematically, the slope = 2z. Where z is the inferred depth.

FINDINGS:

The geology map and magnetic basement depth map of the study area are shown in figures 6 and 7 respectively and were used for interpretation in this work in line with the isostatic rebound theory. The geology map of the study area shows that its SW and NE parts are basement areas. The SW basement contains migmatitic gneiss and coarse porphyritic granite. A segment of the Niger River is seen as a NW- SE diagonal feature cutting across the SW basement. In between the basement areas is a diagonal NW-SE sedimentary basin – the Bida Basin. The magnetic basement depth map (figure 7) shows that the sedimentary part of the study area is a crustal depression whose bottom depth range is up to 3.3 – 4.4 km (Nwofor et al., 2018). The basement at the NE part of the study map has a depth range of 2.2 -2.5 km while the basement at the SW part of the study map has a depth range of 1.8 – 2.5 km and is seen as an uplift representing a river anticline. A qualitative evaluation of the TMI map (figure 2) and residual map (figure 5) shows that the magnetic signals at the SW part of the study area show much red colouration which represents high magnetic values in the TMI map. High magnetic values over an area support the existence of an uplifted magnetic basement within such areas. The uplift structure inferred at the SW part of the study map by the TMI, residual, and magnetic basement depth maps depicts the river anticlines parallel to the Niger River course shown in the geology map.

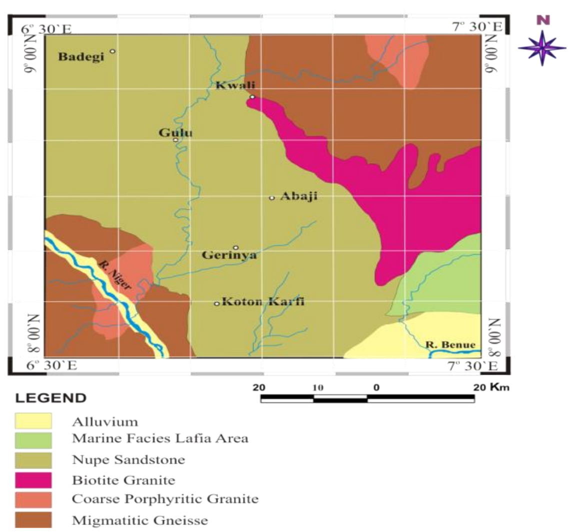

Figure 6: Geology map of the study area.

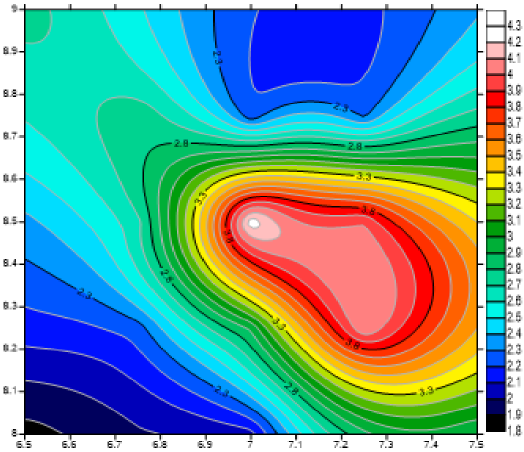

Figure: 7 Magnetic Basement Depth (D2) Map of the Study Area

Conclusions:

The results of these maps go to preliminarily support the formation of the river anticlines parallel to the major river courses. The TMI map and the magnetic basement depth map from the spectral analysis of the residual map of the study area inferred an uplift that depicts the river anticlines parallel to the river course of the Niger River. This is a preliminary study of river anticlines using aeromagnetic data maps and 2-D spectral analysis; we recommend that more digital aeromagnetic sheets covering more segments of the Niger River should be acquired for further geophysical investigation to ascertain the continuity of the uplifts (river anticlines) parallel to the Niger River course.

Acknowledgement:

The authors are grateful to the Federal University of Technology, Owerri, Nigeria for sponsoring this research work. We also wish to thank the Nigerian Geological Survey Agency (NGSA) for all their support. NGSA released the high resolution aeromagnetic (HRAM) data and the geo-scientific softwares used in this study.

Reference

[1]. Ahmed, S. A., Ahmed, A. E., Ashraf, E. G., Sami, H. A. & Marwan, A. A. (2013). Applications of aeromagnetic data to dectect the Basement Tectonics of Eastern Yemen region.Egyptian Journal of Petroleum, 22(2), 277-292.

[2]. Burbank, M. & Bullen, A. M. (1999). Partitioning of intermontane basins by thrust-related folding, Tien Shan, Kyrgyzstan. Basic Research, 11(1), 75-92 DOI: 10.1046/j.1365-2117.1999. 00086.x

[3]. Ladipo, K. O. (1988). Paleogeography Sedimentation and Tectonics of the upper Cretaceous Anambra Basin, South-eastern Nigeria. Journal of African Earth Sciences, 7: 865 – 871.

[4]. Montgomery, D. R. & Stolar, D. B. (2006). Reconsidering Himalayan river anticlines. Geomorphology, 82(1-2), 4-15 DOI: 10.1016/j.geomorph.2005.08.021

[5]. Milne, G. & Shennan, I. (2013). “Isostasy: Glaciation-Induced Sea-Level Change”. In Elias, S. A. & Mock, C. J.(eds.). Encyclopedia of Quaternary Science, (2nd ed.). Elsevier. 452-459.

[6].

[7]. Nwofor, V. U., Opara, A. I., Echetama, H. N., Emberga, T. T. &Inyang, G. E. (2018). Magnetic basement depth and structure over parts of Bida Basin, Nigeria.Interpretation from 2-D SpectralAnalysis and 3-D Euler Decovolution. Australian Journal of Basic and Applied Sciences, 12(9), 1 – 9 DOI: 10.22587/ajbas.2018.12.9.1

[8]. Obaje, N.,Wehner, H.,Scheeder, G., Abubakar, K. andJauro, A. (2004).Hydrocarbon prospectivity of Nigeria’s inland basins.From the viewpoint of organs geochemistry and organic petrology AAPG Bulletin 88(3), 325 – 353.

[9]. Obaje, N., Musa, M., Odoma, A. &Hamza, H. (2011). The Bida Basin in North-central Nigeria sedimentology and petroleum geology. Journal of petroleum and Gas Exploration Research, 1(1), 001 – 013.

[10]. Ojo, S. B. (1984). Middle Niger Basin revisited: Magnetic Constraints on Gravity Interpretation Abstract, 20th Conference of the Nigeria Mining and Geosciences Society, Nsukka, 52 – 53.

[11]. Reeves, C. (2005). Aeromagnetic Survey: Principles,

[12]. Practice and Interpretation.

[13]. Robl, K., Stuwe, K. & Hergarten, S. (2008). Channel profiles around Himalayan river anticlines: constraints on their formation from digital elevation model analysis. *Tectonics*, 27(3), n\a DOI: 10.1029/2007TC002215

[14]. Spector A and Grant, F. S. (1970) Statistical models for interpreting aeromagnetic data Geophysics, 35, 293 – 302.

[15]. Udensi, E. E. & Ozazuwa, I B. (2004). Spectral determination of depths to magnetic rocks under the Nupe Basin, Nigeria.Nigerian Associations of Petroleum explorationists (NAPE), Bull 17, 22 – 27.