



AEROMAGNETIC CHARACTERIZATION OF SUBSURFACE STABILITY IN MPAPE ABUJA NORTH CENTRAL NIGERIA

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Received 29-08-2025

Accepted 11-05-2026

Published on line 19-05-2026

Dates to be inserted by editorial office

Abstract

The objective of this study is to interpret the structural stability of Mpape against the catastrophic earth tremor leading to loss of lives and materials and also to assess how safe the subsurface is for engineering construction. Analysis of high-resolution aeromagnetic data of Mpape Abuja sheet 106 was processed and filtered using the Tilt derivative filter (TDR a geophysical image enhancement technique) and advanced analytic signal—Hilbert solution filter (a complex value representation using Hilbert filter solution) to map out trends of both major and minor structures within the study area. The lineament plot was extracted and plotted; these revealed a dominant NE–SW and NW–SE trending fault linked to the regional offshore Romanchi fault line (Niger Delta) cutting through Gwagwalada, Gwarimpa, and Mpape. Seismic energy is stored and transmitted through these structures, resulting in tremor activities in Mpape. It is therefore wrong to say the study area is free from tremor occurrences.

Refer to Instructions to Authors

Keywords: Aeromagnetic data, Structures, Subsurface stability, Mpape Tremor.

Introduction and literature review

An earthquake or tremor is the result of the release of energy deep underground, which causes seismic waves through the earth's crust "Lowrie, W. (2007)". "This result in rapid rattling of the earth, causing objects to fall from shelves", breaking of glasses, small cracks on walls, and uprooting of trees Elizabeth (2024). Earthquake energy is generated by a sudden dislocation of the crust when the buildup of stress exceeds that of the rock mass; the rock sometimes ruptures and assumes a new position NGSA (2018). These various processes generate seismic waves, which travel in all directions from the point of initial rupture. Ben (2012) stated that tectonic plates are constantly moving slowly over geologic time, but sometimes friction between them causes them to

lock together and become unable to move; then the waves release energy and move through the earth's crust to cause tremors. Recent seismic events in Kwoi, Kaduna State 2016, and Mpape, Abuja 2018, with visible cracks on building with magnitude between 2.1. - 3.0 Richter scale, suggest the stable shield is gradually transitioning into an unstable one Ajakaiye *et al.*, (1991). Seismic activities have also been reported in different parts of Nigeria since 1933 Adepelumi *et al.*, (2018). Earthquakes occur within the West African sub region in countries like Ghana, Ivory Coast and Liberia, Sierra Leone and Guinea Kogbe and Delbos, (1984). Evidence of tremor in Nigeria has eroded the cautious optimism once held that Nigeria is aseismic Akpan (2010). Earthquakes/tremors tend to be concentrated in a particular zone that coincide with the boundaries of tectonic plates; such boundaries may be convergent or divergent boundaries. Adepelumi *et al.*, (2018), reported that the NE-SW and NW-SE (Regional Romanchi and Ifewara Zungeru Fig. 1) conjugate set of strike-slip faults traceable to Mpape must have played a critical role in the generation of seismic energy responsible for the tremor. The faults are characterized by a dextral sense of movement and are traceable to the coastline McMurry (1976). Mpape extension of Maitama, Abuja, in the Federal Capital Territory, is within the city center, and as such, there is a need for a holistic review or examination of the subsurface structure to mitigate and forestall failure and collapses of engineering structures such as buildings and roads during every seismic activity.

Experimental Methods

The aeromagnetic data used for this study is from a high-resolution airborne survey coverage in Nigeria by Fugro survey at 826,000 along a series of NW–SE flight lines of magnetic survey flown at 500 m line spacing and 80 m terrain. It was obtained from the Nigerian Geological Survey Agency (NGSA) to measure the magnetic field. The total magnetic intensity grid was generated using a maximum curvature algorithm at a grid cell size of 1,000; the digitized data was filtered using a low-pass Fourier domain sub-routine filter to eliminate unwanted wavelengths. The data was further co-registered to the Universal Transverse Mercator co-ordinate system zone 32 of the Northern Hemisphere with the use of Geosoft Oasis Montaj 8.4, Discover12, and ArcGIS to create the GIS environment for the integration of the interpreted result. Two-dimensional Fast Fourier Transformation (2DFFT) filter was applied to enhance the quality of the data. The derivative filter and lineament extraction were used to enhance the structure within the study area. (2DFFT offers significant advantages in digital image processing and 2D signal analysis).

Results and Discussions

High-resolution maps were created from the magnetic dataset to depict the subsurface anomaly. Numerous extensive faults were observed within the study area, cutting into Gwarinpa and Mpape. The regional Romanchi fault, with a NE-SW trend, extends from the North Atlantic Ocean into Nigeria; the interconnectivity with other local geological structures serves as conduits through which seismic energy travels Amenyoh (2015). First vertical derivative (FVD) map of the study area Fig 4, and the adjoining area map showing different magnetic anomalies corresponding to different lithology. The long linear features trend in the NE-SW direction, representing lithological boundaries, which could be interpreted as regional fault lines, while the short linear features, with their orientation trending mostly NW-SE and E-W and N-S, are within Mpape, the study area these structures are believed to serve as conduit responsible for the transmission of seismic energy responsible for tremor activities. The intensity of the bipolar structure within Mpape, Bwari, Kubwa, and Gwarimpa is indicative of intense deformation and probable weakness of subsurface geology.

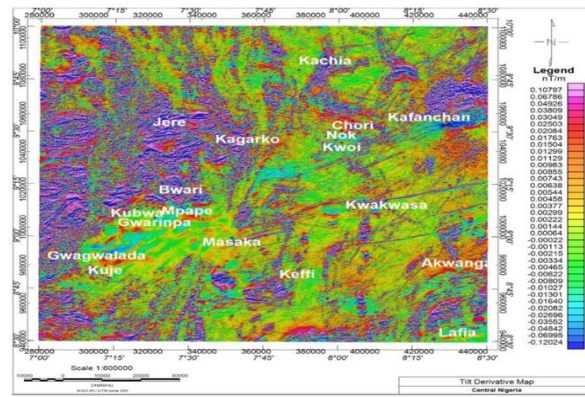


Figure. 4: First vertical derivative map of Mpape and the adjoining area

Lineament was extracted from the first vertical derivative to aid structural intensity and also to evaluate the deformation stability of the local geology. The lineament map fig.5a shows the dominance of NE–SW and NW–SE structural trends with minor E–W trends. The lineament extraction was used to compute the lineament density map with the view to understand the significance of discontinuity, which essentially indicates the density of lineament/structure at a particular location. Areas with high lineament density indicate high deformation (central part of the study area) and low structural stability, while areas with less lineament density (northeastern part) indicate low deformation and high structural stability in tandem with the regional Romanchi fault line responsible for the tremor. Fig. 5b below.

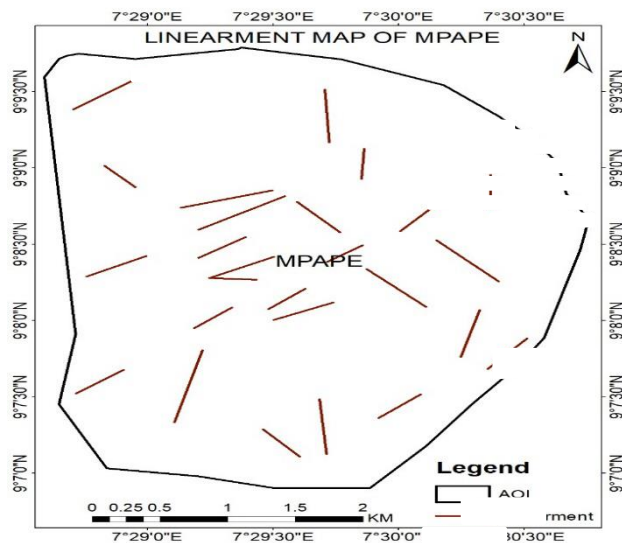


Figure.5a lineament map of the study area

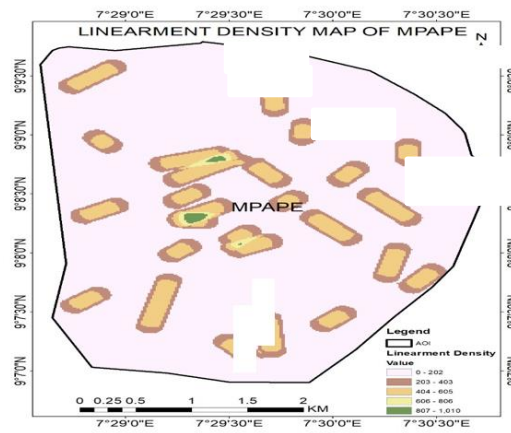


Figure.5b lineament density map of the study area

Conclusions

Analysis of the Mpape, Abuja tremor in north-central Nigeria to investigate subsurface stability and examine the safety of the study area for engineering construction due to earth tremor occurrence was carried out. The NE–SW regional Romanchi fracture from the Atlantic Ocean plays an important role in the source of seismic energy responsible for earth tremors in Mpape. The seismic energy transferred in the NE–SW direction gets into contact with some angular N–S and parallel NE–SW local fault lines, hence causing a large accumulation resulting in tremor activities observed in Mpape, central Nigeria. Local fault lines within Mpape are becoming activated, as indicated on September 7, 2018, and by the recent tremor activities from the 13th all the way to the 16th of September 2024. The tremor recorded a 3.0 magnitude on a Richter scale with the epicenter located in Mpape and various aftershocks around other locations. It is pertinent at this juncture that strict adherence to seismic building codes and smart structural design with appropriate materials and construction protocols is advised to avoid further catastrophe.

Acknowledgements

The authors wish to express their sincere appreciation to the management of National Space Research and Development Agency and also the management of Paau for their valuable contributions towards provision of materials used for this study.

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