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TECTONIC INTERPRETATION OF BASEMENT STRUCTURES IN IJEBU-ODE AREA USING AEROMAGNETIC METHOD

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Abstract
The Ijebu-Ode region in southwestern Nigeria forms part of the Nigerian Precambrian Basement Complex, characterized by multiple tectonic imprints resulting from Proterozoic to Phanerozoic events. This study applies high-resolution aeromagnetic data processing — including Analytic Signal Amplitude (ASA), Euler deconvolution (Structural Index = 1), and integrated structural mapping — to delineate major fault systems and assess their tectonic significance. Results reveal NW–SE and NE–SW trending fault systems consistent with Pan-African deformation, overprinted by later reactivation phases. Interpretation suggests a polyphase tectonic history involving crustal collision, transcurrent shearing, and later extensional reactivation, which influenced crustal architecture and structural deformation. The findings refine the tectonic model for the region and contribute to understanding deformation patterns in similar West African basement terrains.

1. Introduction

Tectonic interpretation of basement complex regions requires integrated analysis of geophysical data, structural geology, and regional tectonic evolution models (Rahaman, 1988; Caby, 1989). In southwestern Nigeria, the Nigerian Basement Complex exhibits structural fabrics largely shaped by the Pan-African Orogeny (~600 Ma), with earlier imprints from Kibaran (~1.1 Ga) and Eburnean (~2.0 Ga) events (Dada, 2006; Ajibade & Fitches, 1988). These fabrics have been variably reactivated during Mesozoic–Cenozoic tectonism linked to the opening of the Atlantic Ocean (Burke & Dewey, 1972).

Aeromagnetic methods are particularly effective for detecting basement structural patterns beneath tropical weathering profiles (Reeves, 2005; Ojo et al., 2019). In regions like Ijebu-Ode, where surface mapping is hindered by vegetation cover and limited outcrops, magnetic anomaly interpretation provides a crucial window into subsurface tectonics (Ekwok et al., 2022). This study aims to:

1. Delineate major basement structural features from aeromagnetic data.
2. Interpret the tectonic history reflected in the mapped fault systems.
3. Relate local structures to broader West African tectonic trends.

2. Literature Review

The Nigerian Basement Complex is a segment of the Pan-African mobile belt, which sutures the West African and Congo cratons (Black et al., 1979; Caby, 1989). Its structural grain is dominated by NE–SW and NW–SE trending shear zones, thrust faults, and fold belts (Rahaman, 1988; Ajibade & Fitches, 1988).

Regional studies (Benkhelil, 1989; Ajibade, 1982) suggest that these fabrics formed during continent–continent collision, with subsequent transtensional deformation linked to transcurrent fault systems. Similar trends are observed in the Dahomeyide Belt, extending into Benin and Togo (Affaton et al., 1991).

Aeromagnetic studies in the West African basement have mapped concealed shear zones, intrusions, and reactivated faults (Adepelumi et al., 2008; Ojo et al., 2019). The ASA technique effectively highlights lithologic contacts and fault traces, while Euler deconvolution provides depth estimates to magnetic sources (Reid et al., 1990; Salem et al., 2002).

In southwestern Nigeria, Ekwok et al. (2022) and Fatoba & Kehinde (2017) identified Pan-African shear zones trending NW–SE and NE–SW, many of which coincide with major crustal discontinuities inferred from gravity data (Anakwuba et al., 2011).

Globally, tectonic interpretations of aeromagnetic datasets have been applied in Precambrian shields such as the Canadian Shield (Hynes & Rivers, 2010), East Antarctic Shield (Guy et al., 2024), and the Brazilian Craton (Machado et al., 1996), revealing the value of such approaches in resolving crustal architecture.

Despite these advances, no detailed aeromagnetic tectonic study has been focused on Ijebu-Ode, leaving a gap in understanding how local fault systems fit into the regional deformation history. This study addresses that gap by providing a high-resolution, interpretation-driven assessment of the tectonic evolution of Ijebu-Ode.

3. Methodology

3.1 Data Source

Aeromagnetic data covering Ijebu-Ode were obtained from the NGSA. The survey was conducted with a flight line spacing of 500 m, tie-line spacing of 2 km, and an average terrain clearance of 80 m.

3.2 Data Processing

Data processing was carried out using Oasis Montaj:

- **Analytic Signal Amplitude (ASA)** for mapping source edges.
- **Euler Deconvolution (Structural Index = 1)** for depth estimation of dike-like structures and faults.
- Final **structural map** compiled by integrating ASA and Euler interpretations.

4. Results

4.1 Analytic Signal Amplitude (ASA) Map

The ASA map (Figure 1) highlights high-amplitude zones trending NW–SE and NE–SW, corresponding to major fault traces and lithologic boundaries. Several anomalies are continuous for over 10 km, suggesting deep-seated crustal features.

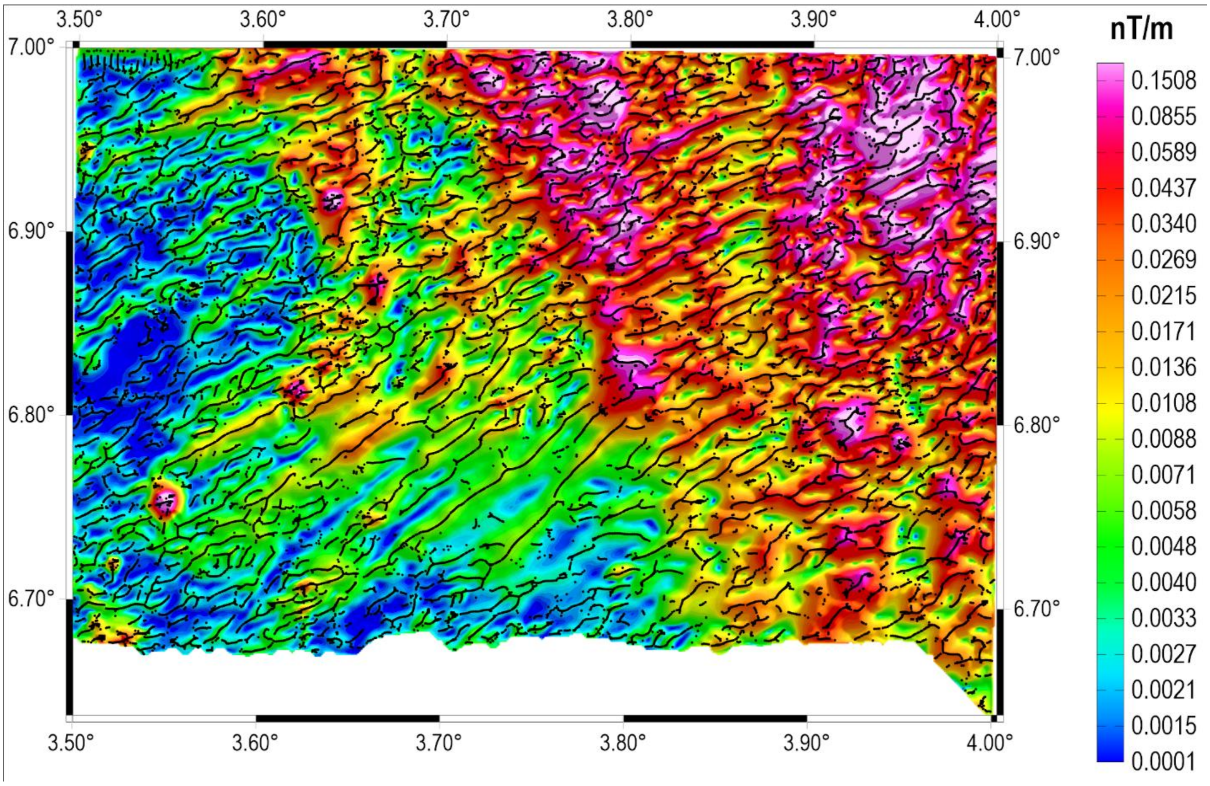

Figure 1. Analytic Signal Amplitude map of Ijebu-Ode showing mapped structural edges.

4.2 Euler Deconvolution Map

Euler depth solutions (Figure 2) reveal that most major faults extend to depths of 2–4 km, with some anomalies exceeding 5 km, indicating crustal-scale features. Clusters of solutions coincide with ASA peaks, validating the structural interpretations.

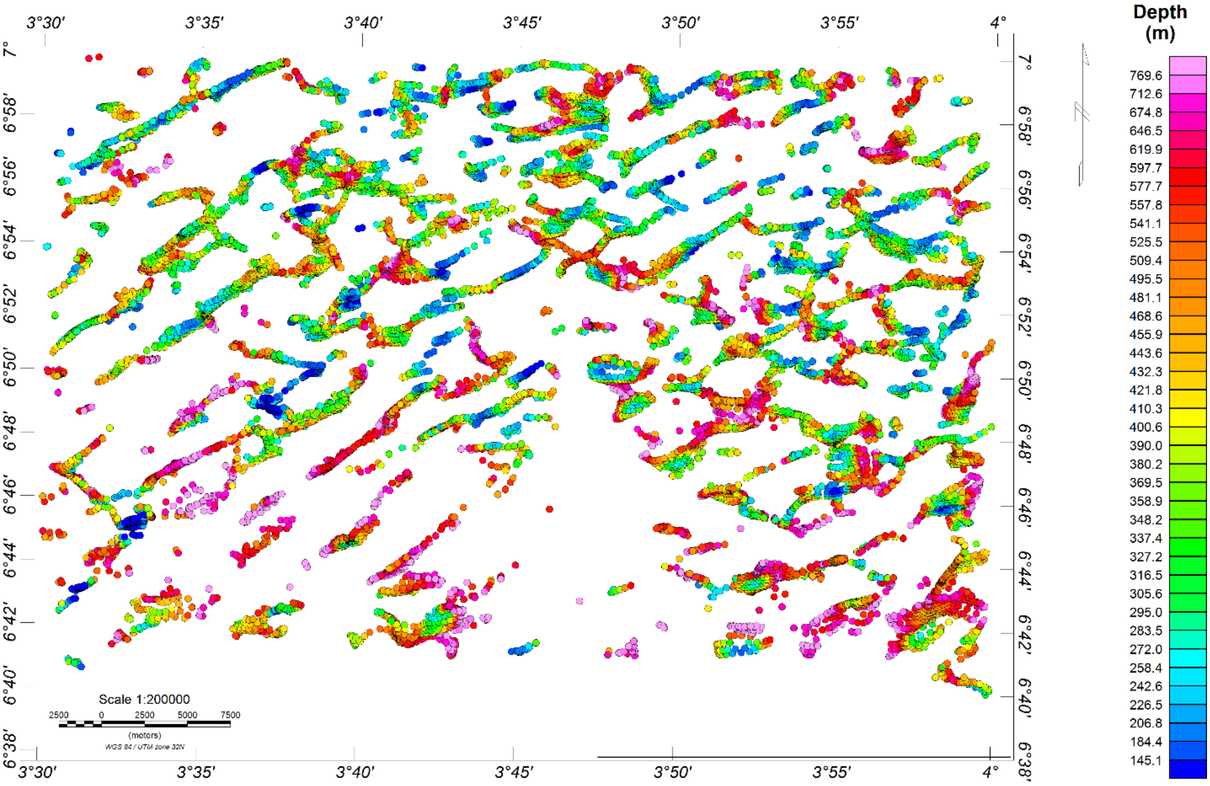

Figure 2. Euler Deconvolution map (SI = 1) showing depth estimates and fault locations.

4.3 Structural Map

The integrated structural map (Figure 3) shows dominant NW–SE and NE–SW fault systems, intersected by E–W and minor N–S structures. Fault intersections mark high-strain zones, likely acting as conduits for hydrothermal fluid flow during deformation events.

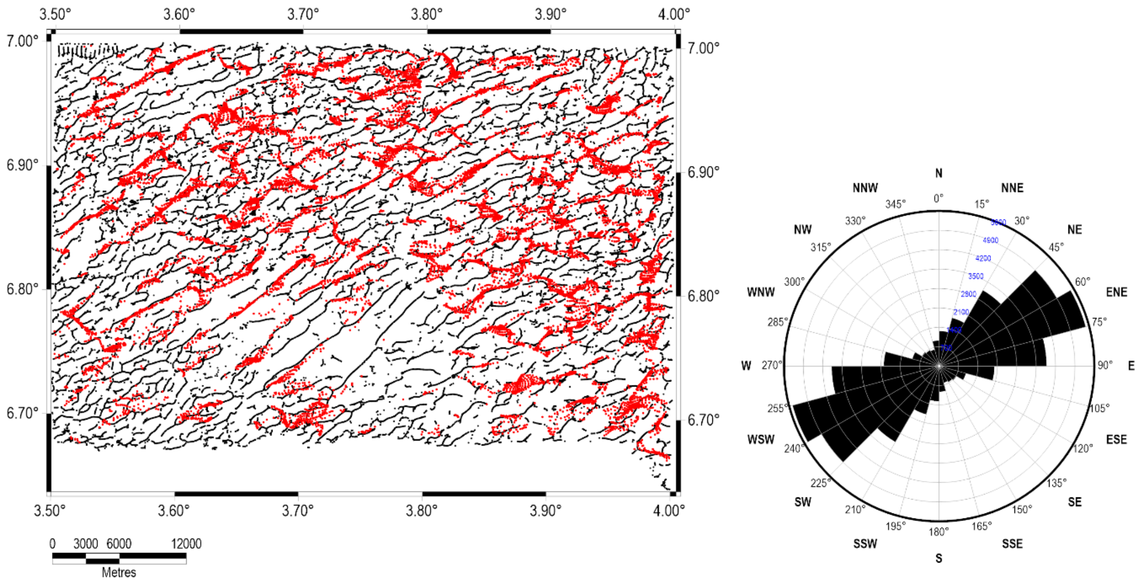

Figure 3. Structural map of Ijebu-Ode showing interpreted fault systems and deformation patterns.

5. Discussion

The NW–SE trending faults likely formed during the main Pan-African collisional phase, reflecting compression between the West African and Congo cratons (Caby, 1989; Black et al., 1979). The NE–SW faults may represent conjugate shear zones formed during the same event, later reactivated under different stress regimes (Ajibade & Fitches, 1988; Affaton et al., 1991).

The presence of E–W faults suggests pre-Pan-African structures possibly related to Kibaran tectonism (~1.1 Ga), reactivated during Pan-African or later Mesozoic extension (Dada, 2006; Burke & Dewey, 1972). The Euler-derived depths of up to 5 km indicate that these faults are crustal-scale features capable of influencing basin development and fluid migration (Anakwuba et al., 2011; Ekwok et al., 2022).

The structural intersections identified could have acted as loci for brittle failure, mineralization, or geothermal activity, similar to findings in the Brazilian Craton (Machado et al., 1996) and East Antarctic Shield (Guy et al., 2024).

6. Conclusion

Aeromagnetic interpretation has revealed a polyphase tectonic history for Ijebu-Ode, involving Pan-African compression, transcurrent shearing, and later extensional reactivation. The identified fault systems form an integral part of the regional West African tectonic framework, and their depth extent underscores their geological significance.

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