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Multi-structural Mapping of Subsurface Geological Features in Omu-Aran and Environs using 3D Euler Deconvolution of Aeromagnetic Data

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Abstract*— High-resolution aeromagnetic data over Omu-Aran and its environs have been analyzed to map different types of subsurface geological structures in the area. The data were filtered by upward continuation and then subjected to 3D Euler Deconvolution (ED) using multiple structural indices, which range from 0 to 3. The filtered map showed slightly smoother anomalies, which indicate an increased signal-to-noise ratio. The Euler solutions obtained showed the locations, orientation and depths of different types of geological structures, including contacts, faults, pipe-like structures, and spherical/compact bodies. These solutions were compiled to produce a geological structural map for the study area. The geological structures having high structural indices were mostly located at deeper depths than those having low structural indices. The results also showed that the geology of Omu-Aran and its environs is highly structurally dissected by faults and dike-like structures, among other geological structures. The subsurface structures trend dominantly in the NNE-SSW and ENE-WSW directions. Five potential zones of high structural complexity were identified and two fault zones oriented in the NNE-SSW and ENE-WSW directions were also mapped. The NNE-SSW fault zone was considered a part of the Ifewara Fault zone. The dominant trending structures in the study area were attributed to the continental extension of Atlantic Fracture Zones and Pan-African Orogeny. The geological structures identified in the study area were recommended as potential targets in the search for mineral deposits and for regional groundwater prospecting in Omu-Aran and its environs. The fault zones identified in this study were, however, not recommended as locations for siting man-made infrastructure such as buildings and bridges.

Keywords*— *Structural Mapping, Geological Structures, Fault Zone, Euler Deconvolution, Magnetic Method

I. Introduction

The Earth's subsurface is a complex network of geological structures that are critical to our understanding of the Earth's dynamics and distribution of natural resources. Geophysics provides powerful means of visualizing and studying these structures, which can range from simple faults and folds to very complex underground geological formations [1]–[4]. One of the most effective and non-invasive geophysical approaches to image these structures is by using the magnetic method, which exploits the contrasts in the magnetization of subsurface rocks [5]. The magnetic method is based on the principle of magnetism, which shows that some minerals in rocks, such as magnetite, have magnetic properties that can create a measurable magnetic field. The differences in the magnetization of the rocks cause local spatial variations, known as anomalies, in the Earth's magnetic field [6]. These anomalies can be measured and interpreted to reveal the geometry and magnetic properties of the causative rocks, and as well, create depths and location maps of the subsurface geological structures [3], [7], [8]. However, the process of identifying these structures from magnetic anomaly data involves advanced analysis and interpretation techniques, among which is the Euler Deconvolution (ED) method.

The ED method is a powerful and widely-used technique for fast imaging of geological structures in oil and gas exploration, solid mineral exploration and geophysical studies [7]–[11]. The method was first introduced by [12] for magnetic profile interpretation and extended to 3D for gridded data by [13]. The 2D and 3D ED equations were both derived from Euler's homogeneity equation and are solved numerically to estimate the location and depth of the source body. The ED method uses the relationship between the geometry of the subsurface structure, defined by a parameter called structural index, and the spatial derivatives of magnetic or gravity anomalies. One key advantage of ED is its ability to reliably estimate the depths