Submission code: MZKQ7KL8Z7

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Evaluation of Enhancement Filters in Aeromagnetic Data for the Identification of Riacho do Cordeiro Dike Swarm, NE, Brazil

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Introduction

Accurate mapping of subsurface geological features that are hidden from direct observation is fundamental to mineral exploration. Aeromagnetic surveys are vital tools for this purpose, enabling the detection and characterization of concealed structures. A key aspect of analyzing such potential field data is the precise identification of geological boundaries, which significantly enhances the interpretation of geological body geometry and distribution. Consequently, various filtering and data enhancement methods have been extensively developed and employed to refine the resolution and interpretability of magnetic datasets.

Among these techniques, edge detection algorithms are particularly effective for revealing geological contacts, faults, lineaments, and other structural elements essential to understanding tectonic configurations. Mafic dikes represent a key geological target in these analyses. These typically subvertical, tabular intrusions — often forming extensive swarms — serve as key indicators of the continental crust's tectonic and magmatic history. Analyzing their spatial patterns helps decipher crustal deformation styles and reconstruct a region's geodynamic evolution.

The Borborema Province in northeastern Brazil contains significant examples of these dike swarms, such as the Riacho do Cordeiro dike swarm (targeted in this study). These dike swarms are linked to Mesozoic magmatism and potentially associated with the early stages of South Atlantic Ocean formation. Therefore, this study focuses on evaluating the performance of various aeromagnetic data enhancement and edge detection techniques, specifically assessing their effectiveness for laterally delineating mafic dike structures.

Method and/or Theory

This study utilized aerogeophysical data from the Paraíba–Rio Grande do Norte and Paulo Afonso–Teotônio Vilela projects, which were carefully integrated through geophysical stitching processes to form a grid, capable of covering the entire Riacho do Cordeiro dike swarm. The Total Magnetic Intensity (TMI) map was first processed using the Pole Reduction (RTP) filter to remove dipole effects. From the RTP map, several enhancement techniques were applied and compared for structural delineation, including: Directional Derivatives (Dx, Dy and Dz), Total Gradient (TG), Total Horizontal Gradient (THG), Azimuth, Vertical Integration (VI), Total Gradient of the Vertical Integration (GTVI), Tilt Derivative (TDR), Horizontal Tilt Angle (TDX), and Second-Order Step-Edge Detection (SSTE).

Results and Conclusions

The application of various aeromagnetic filters clearly revealed a dominant lineament with a preferential orientation, interpreted as a mafic dike extending across the entire map area. Among the tested methods, the Azimuth, DX, TDR, and the combined TDX + TDR filters proved to be the most effective in delineating the dike, clearly outlining its boundaries and continuity. The GTVI and Dz filters also contributed by revealing internal structural variations within the body. In contrast, the SSTE filter was excessively noisy, which hindered the clear delineation of the feature. Overall, the comparative analysis enabled the identification and ranking of the most suitable filters for this type of structural interpretation. Furthermore, unsupervised machine learning techniques will be employed to quantitatively assess and classify the filter that demonstrated the highest performance in enhancing dike-related features.