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Morro São João Alkaline Complex: 3D Magnetic Modeling with Remanence Correction and Petrophysical Constraint

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Introduction

Investigating alkaline massifs, such as the Morro São João Alkaline Complex (MSJAC) in southeastern Brazil, is fundamental to understanding magmatic processes, lithospheric evolution, and post-collisional tectonic dynamics. The MSJAC is part of the eastern Serra do Mar Igneous Province (SMIP), where Early Cretaceous alkaline intrusions were emplaced within the Brasiliano (Pan-African) Ribeira Belt, reflecting lithospheric reactivation linked to the opening of the South Atlantic Ocean. Despite numerous geological and structural studies in the region, detailed geophysical investigations to constrain these complexes' internal architecture and emplacement dynamics remain limited.

Previous magnetic modelling over the MSJAC assumed that the total magnetisation aligns with the present geomagnetic field. However, this simplification neglects the significant remanent magnetisation typical of alkaline rocks, potentially distorting geometry, depth, and volume estimates. This limitation reinforces the need for workflows incorporating remanence correction in magnetic inversion.

Materials and method

This study integrates aeromagnetic data with two key a priori constraints. The first involves estimating the total magnetisation direction—inclination and declination—using the Equivalent Layer (EL) technique with positivity constraint, allowing robust correction for remanence.

The second constraint incorporates magnetic susceptibility values measured from representative rock samples collected in the field, enhancing the geological validity of the model.

The 3D inversion was performed using both constraints, providing a refined subsurface geometry and magnetic property distribution for the Morro São João Alkaline Complex.

Results and Conclusions

The refined inversion improved the accuracy of the recovered model, correcting the geometry, depth, and spatial positioning of the magnetic source relative to models that ignored remanence. The results delineate a moderately elongated, subhorizontal intrusive body with internal heterogeneities likely related to magmatic pulses or structural controls during emplacement.

This approach demonstrates the importance of accounting for remanent magnetisation in magnetic inversion, particularly for alkaline complexes. Integrating magnetisation direction estimation and field-based susceptibility constraints produces a geologically coherent 3D model that aligns with geophysical observations and the regional geological context. The methodology improves the MSJAC's understanding and applies to similar alkaline systems worldwide.