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Insights into the Goiás Magmatic Arc Lithosphere from Three-Dimensional Magnetotelluric Data

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Introduction

The tectonic evolution of Neoproterozoic magmatic arcs, such as the Goiás Magmatic Arc (GMA) in the Tocantins Province (TP), remains insufficiently understood, largely due to the overprinting effects of post-subduction events. These processes obscure primary arc-related structures, making it challenging to reconstruct the geodynamic history of such systems. In the case of the GMA, fundamental questions remain unanswered, including the nature of its deep tectonic framework and the reason behind the structural confinement of Goiás Alkaline Province (GAP) to the western portion of the Arenópolis segment (GMAA). It comprises of arc-related meta-igneous and metasedimentary rocks that developed during the collision among the Amazon, São Francisco, and Paranapanema cratons. Due to its complex evolution, the GMA exhibits contrasting geological and geophysical characteristics that support its current segmentation into the Mara Rosa segment (north), Arenópolis segment (southeast), and Anicuns-Itaberaí segment (southwest).

In recent decades, the magnetotelluric (MT) method has proven to be an effective tool for imaging deep lithospheric structures across various tectonic settings, particularly through large-scale MT arrays deployed in countries such as the USA, Australia, and China. Although Brazil has several long-period and broadband MT profiles, few studies using regular grid-based MT arrays have been conducted to date. This study proposes the first long-period MT acquisition on a 50 km regular grid in a Magmatic Arc in Brazil, followed by data processing, 3D inversion, and integration with other geological and geophysical datasets. This integrated approach aims to characterize the tectonic framework of the Arenópolis and Anicuns-Itaberaí segments of the Goiás Magmatic Arc and to investigate the factors responsible for the emplacement of the GAP.

Method and/or Theory

Magnetotellurics is a passive electromagnetic method used to investigate the electrical properties of the Earth's crust and mantle by measuring orthogonal components of the magnetic (H) and electric (E) fields at the surface in the time domain.

Data acquisition was carried out over a three-months during the 2023 dry season in the of Goiás. A total of 34 long-period MT stations were installed. Each station recorded magnetic and electric fields continuously for 2 to 3 weeks, using 100-meter dipoles. Data processing employed robust statistical methods to ensure high-quality estimates of resistivity, phase, and tensor components. Dimensionality analyses using multiple approaches consistently indicated a predominantly 3D anisotropy. The full 3D inversion of the dataset was performed using the ModEM software.

Results and Conclusions

The resulting 3D resistivity model (nRMS = 1.21) reveals distinct lithospheric structures across the GMAA. In the western portion, the model indicates significant variations in crustal thickness and resistivity, whereas the eastern portion is characterized by higher resistivity and a thicker lithosphere, likely associated with São Francisco Craton. The absence of a continuous conductive feature along the Moiporá–Novo Brasil shear zone suggests that these segments may represent splays of the Transbrasiliano Lineament. This supports the interpretation that both portions of the GMAA evolved along the same subduction front and were amalgamated during the final stages of the Brasiliano orogeny. The confinement of the GAP to the western GMAA is likely related to the shielding effect exerted by the cratonic mantle lithosphere underlying the eastern portion. These results highlight the efficiency of MT method for regional-scale investigations of crustal and lithospheric structure.