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Magnetotelluric Mapping of Deep Crustal Conductors Related to Gold Deposits in the Goiás Greenstone Belts, Preliminary results from the MT Brazil Project

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Introduction

The Goiás greenstone belts, including Crixás, Guarinos, Pilar de Goiás, Faina, and Serra de Santa Rita, are predominantly Archean to Paleoproterozoic geological formations composed of volcano-sedimentary sequences embedded in granitoid-gneissic terranes of the Archean Goiás Block. These geological units comprise ultramafic and mafic rocks, such as komatiites and tholeiitic basalts, as well as metasedimentary rocks, including banded iron formations (itabirites), quartzites, pelitic schists, and carbonate formations.Gold mineralization in the region is predominantly orogenic, occurring in quartz-sulfide veins primarily hosted within metapelitic units and itabirites. This mineralization is commonly associated with shear zones formed during Paleoproterozoic tectonic events and subsequently reactivated during the Neoproterozoic Brasiliano Orogeny. Significant deposits include the world-class Serra Grande (Crixás) and Pilar (Pilar-Guarinos) complexes, both characterized by substantial gold reserves exceeding millions of ounces. Metamorphic dehydration of oceanic crust rocks during the transition from greenschist to amphibolite facies is considered the primary mechanism responsible for releasing metal-bearing fluids. However, identifying whether a crustal signature is associated with these gold deposits remains challenging due to the overprint effects of the Neoproterozoic and the wide depth range (10–30 km) of the greenschist–amphibolite facies transition. Understanding the potential crustal controls, their extent, and the preservation processes of these signatures is essential for advancing metallogenic models and optimizing exploration strategies.

Methods

We employed the Magnetotelluric (MT) method, integrated with magnetic and gravity data, to investigate crustal signatures related to gold mineralization in the Goiás greenstone belts. These methods enable a bottom-up analysis of the crust, allowing us to trace the footprint of mineralization and fluid pathways to the surface owing to their deep penetration and high sensitivity to hydrothermal alteration induced by orogenic fluids. We acquired MT data at 18 stations, spaced 50 km apart, with a sampling frequency of 1 Hz for during 20–30 days. The equipment used was the LEMI-417M, equipped with a fluxgate magnetometer. The horizontal orthogonal components of the electric field (Ex and Ey) were calculated using 100-meter dipoles in a crossed configuration with non-polarizable $Pb/PbCl_2$ electrodes. We processed the data using multivariate statistical techniques, with most sites analyzed in remote reference mode. We inverted our data using the Non Linear Conjugate Gradient method.

Results

The preliminary results reveal conductive and magnetic anomalies at different crustal depths, suggesting potential correlations between them. The identified conductive zones and magnetic features indicate structural complexity at various crustal levels, which may be associated with geological processes related to mineralization. The integration of MT, magnetic, and gravity data has proven effective in identifying the deep roots of the mineral system, enabling correlations with mineralization processes and testing the hypothesis that deep conductive zones act as preferential pathways for mineralizing fluids. These findings highlight the importance of integrating geophysical data to characterize the crustal architecture and provide a preliminary framework for further investigations into mineralization processes in the Goiás greenstone belts.