Submission code: 5YNAQJGR6Q

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Unveiling the Geophysical Signature of the Santa Lúcia Cu-Au Polymetallic Deposit: Implications for Mineral Exploration in the Carajás Mineral Province

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Abstract

Copper, a key element in the global energy transition, has intensified the search for new subsurface deposits, which are often blind and geophysically subtle. The Neoarchean-aged Santa Lúcia Cu-Au deposit, located in the southeastern Carajás Domain near Serra do Rabo Ridge, is hosted in rhyolitic subvolcanic rocks of the Grão Pará Group and partially truncated by a pegmatitic intrusion. Studies suggest that Santa Lúcia represents a Cu-polymetallic system distinct from the classical IOCG model.

The application of multisource geophysical methods revealed significant exploration challenges. Magnetic data, both regional and ground-based, showed low contrast due to the weak magnetic susceptibility of the mineralized zone. Three-dimensional inversion confirmed the absence of a strong magnetic response. In contrast, electrical (IP) and electromagnetic (TDEM) methods revealed strong chargeability and conductivity contrasts, enabling the delineation of different mineralized domains. While chargeability effectively detected disseminated sulfides, it was limited in identifying massive sulfide bodies. Resistivity models proved more effective in mapping conductive anomalies associated with mineralization.

Data integration indicates that the Santa Lúcia deposit, dated at 2.7 Ga, can be characterized at the deposit scale as conductive, chargeable, and weakly magnetic, showing similarities to shallower Cu-Au polymetallic deposits dated to around 1.8 Ga.

These results underscore the importance of multisource geophysical and petrophysical integration, particularly using methods sensitive to electrical conductivity, for identifying mineral systems with weak magnetic expression. The Santa Lúcia case highlights the need for combined geophysical strategies to effectively characterize complex mineral systems and uncover hidden exploration potential.