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Geophysical Well-Logging Applied to the Characterization of Mineralized Horizons in the Tapira Mining Complex (MG): Integration of Petrophysical and Geological Data

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Introduction

Core sampling in geological drilling is a valuable technique that allows for the direct analysis of rocks, yet it is often not applied to all drilled boreholes due to its high operational costs. In such cases, indirect methods such as geophysical well-logging serve as a valuable complement by enabling detailed subsurface investigations through the indirect measurement of the physical properties of rocks and their constituent materials. Geophysical logging employs specific tools to continuously measure these properties along the borehole, generating detailed profiles after data acquisition and processing.

Method and/or Theory

This study aims to interpret and correlate petrophysical data acquired through gamma-gamma density logging (HDGS) in three boreholes within the Tapira Mining Complex (CMT), in Minas Gerais, with geochemical data and petrographic descriptions. This integration enabled the detailed characterization of the different horizons within the weathering profile. The CMT is composed of alkaline-carbonatitic rocks such as bebedourites and carbonatites, belonging to the Alto Paranaíba Igneous Province, of Late Cretaceous age. The complex is characterized by a thick weathering mantle formed through the chemical alteration of these original rocks, promoting the remobilization and economic concentration of phosphate, titanium, and rare earth elements within specific horizons. These horizons, from top to bottom, are defined as: alloterite, upper and lower isalterite, semi-weathered rock, and fresh rock.

Results and Conclusions

Densities recorded by gamma-gamma logging ranged from 1.54 to 3.30 g/cm³, showing consistent correlation with the petrographic and geochemical data obtained. Detailed lithochemical analyses via SEM-EDS and micro-X-ray fluorescence (micro-XRF) provided insights into the textures and structures of the bebedourites and carbonatites, as well as the identification of distinct generations of veins composed of phlogopite-picrite, bebedourite, and carbonatite. Geochemical results confirmed the expected compositions for the analyzed lithologies, enabling the clear identification and differentiation of the mineralized horizons along the investigated profiles. The integration of geophysical methods with petrographic and geochemical techniques proved to be highly effective in the accurate characterization of the CMT horizons, highlighting the importance of an integrated methodological approach in geological and exploratory studies.