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Geophysical Well-Logging Applied for Structural Characterization of the BL-1 Tailings Dam (Tapira Mining Complex, Brazil)

João Paulo Barros (Centro de Pesquisa em Geofísica Aplicada (CPGA/UFRJ)), Laura Paes, Caio de Almeida Paula, Caio Almeida Carvalho, Leonardo Vieira (Centro de Pesquisa em Geofísica Aplicada (CPGA-UFRJ)), Ewerton Rodrigues (MOSAIC), Igor Gama (MOSAIC), Ricardo Telles (MOSAIC), Marco Braga (CPGA-UFRJ), Thiago Oliveira (MOSAIC)

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Introduction

The BL-1 tailings dam, located within the Tapira Mining Complex in Minas Gerais, southeastern Brazil, began operation in 1982 with the primary purpose of containing slurries and ultrafine tailings generated during the beneficiation of phosphate-rich ores. With the growing emphasis on the structural integrity and environmental safety of mining infrastructure in recent years, research on tailings dams has intensified, encouraging the use of advanced technologies such as geophysical methods for monitoring and evaluation. One such technique is borehole geophysical logging, which involves tools that measure specific physical properties continuously along the borehole. After data acquisition and processing, an integrated petrophysical profile is produced.

Method and/or Theory

This study employed natural gamma and gamma-gamma density logging (High-Density Gamma Sonde – HDGS) onalong the borehole BL1-SM10, which was drilled directly into the BL-1 structure. The main objective was to correlate the petrophysical data obtained with the dam's key geotechnical components, namely the tailings beach, the embankment body, the starter dyke, and the foundation substrate. Data acquisition was followed by processing and interpretation, resulting in integrated profiles of natural gamma and bulk density.

Results and Conclusions

The density values measured ranged from 1.66 g/cm³ to 2.55 g/cm³, while natural gamma readings varied between 0 and 1000 API. These variations reflect changes in material composition, compaction, and mineralogical content, allowing a robust geophysical differentiation among the dam's structural components. The integration of these petrophysical profiles with geotechnical models provides valuable insight into the internal layering of the dam body and confirmed the potential of gamma-gamma logging for identifying contrasts in physical properties. These results enabled the correlation of petrophysical properties with dam structures, demonstrating the effectiveness of gamma-gamma logging in acquiring physical parameters throughout the borehole. As a future development, we propose integrating these petrophysical data with surface seismic velocity measurements, aiming to estimate elastic parameters—such as shear modulus—along the borehole. This combined geophysical approach can significantly improve the robustness of geotechnical assessments and contribute to safer and more effective dam monitoring strategies.