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Geological and Geotechnical Characterization Using Electrical Methods for Monitoring the Decommissioning of a tailings dam

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Introduction

The Serra Grande dam, located in the municipality of Crixás (Goiás, Brazil), is operated by AngloGold Ashanti and includes, within its complex, a tailings storage facility (TSF) commissioned in 1989 to store waste generated from gold ore processing. Following recent tailings dam failures in Brazil, such as those in Mariana (2015) and Brumadinho (2019), regulatory demands for safety and continuous monitoring of such structures have significantly increased. In this context, Federal Law No. 14.066/2020 was enacted, mandating the decommissioning of all tailings dams constructed using the upstream raise method throughout the country. The MSG tailings dam comprises seven successive raises, with two executed downstream and five upstream. In compliance with the current legislation, tailings deposition in the structure was ceased in 2021, enabling the initiation of decommissioning works in 2023.

Method and/or Theory

This study aims to correlate electrical resistivity data with variations in the phreatic surface of the tailings dam, between the years 2020 and 2024, through the application of Current Electrical – Electrical Resistivity Tomography (CE-ERT). The investigation also includes the geophysical characterization of the materials that compose the structure. In 2020, a total of 37 electrical resistivity sections were acquired, covering approximately 12,644 linear meters. The survey employed both pole-dipole and dipole-dipole array configurations, with electrode spacings of 5.0 m and 3.0 m, respectively. In the 2024 campaign, six profiles were acquired using only the dipole-dipole array, with a 7.5 m. The identification and monitoring of the phreatic surface were conducted based on readings from 12 Water Level Indicators (INAs), recorded during the geophysical data acquisition periods in 2020 and 2024, providing greater reliability in the interpretation of subsurface saturation conditions.

Results and Conclusions

The results obtained allowed for the structural characterization of the tailings dam and the identification of significant variations in groundwater levels. Between 2020 and 2024, a phreatic surface drawdown of approximately 12 to 15 meters was observed, as evidenced by both resistivity sections and INA (Water Level Indicator) readings. Comparative analysis of the geophysical sections revealed a reduction in low-resistivity zones previously associated with saturated conditions. These areas began to exhibit intermediate resistivity values, indicating an increase in resistivity and, consequently, a potential decrease in moisture content. The resistivity of the water was estimated to be below 40 ohm, based on correlation with INA data. The resistivity sections acquired in 2024, when compared with the geotechnical profiles, showed a direct correlation between the two datasets. It was found that the zones located below the internal drainage system, mostly made up of tailings, had resistivity values of less than 90 ohms, while above the internal drainage there were values in an intermediate zone between 80 and 380 ohms. This clearly identified the influence of the internal drainage system in controlling the distribution of electrical resistivity within the dam structure. The observed reduction in the water table was a decisive factor in starting the de-characterization works and represents a significant step forward in the process of stabilizing the dam. The application of electrical methods proved highly effective in the internal structural diagnosis, allowing the clear and precise identification of the electro resistivity intervals associated with the different physical characteristics of the materials.