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Comparing electrical resistivity tomography surveys using multi-arrays and electrode spacing in an intermittent stream for underground dam study

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Introduction

The study aims to investigate the feasibility of implementing underground dams in an intermittent stream in the semi-arid region of Minas Gerais. For this purpose, an electrical resistivity survey using multi-array and electrode spacing was carried out to determine the thickness of the sediment layer, bedrock depth, and to identify potential fractures zones in the basement rock. Water resources are extremely important for the economic development and survival of people living in small rural communities in semiarid regions, such as the northeast of the state of Minas Gerais. The sites chosen for field survey are located along the intermittent drainage channels of the Stream Bolas, in the municipality of Jenipapo de Minas. The geoelectrical resistivity surveys was chosen since it is an non-invasive method widely employed in hydrogeological and geological studies to characterize subsurface formations and detect structural features. Variations in subsurface electrical resistivity can highlight changes in geological conditions such as the thickness of unconsolidated sediments, bedrock topography, and the presence of fracture systems, which can influence groundwater flow and resource availability.

Methodology

The electrical resistivity tomography (ERT) was carried out by employing Schlumberger, Werner, and dipole-dipole arrays, with 1, 2, and 4 meters electrode spacing. Each electrode configuration offers distinct resolution and depth penetration capabilities: the Schlumberger array is optimal for deep penetration with minimal lateral sensitivity, Werner provides intermediate depth sensitivity, and the dipole-dipole array excels in detecting lateral variations and fractures. Data acquisition was performed systematically along the same profile that intersected the Bolas stream, ensuring both lateral and vertical variations for the characterization of the geological materials in the subsurface. Data inversion was conducted using specialized geophysical software to minimize errors and improve the resistivity model.

Results and Conclusions

The ERT survey allowed the estimation of sediment thickness, mapping of the bedrock interface, and the identification of a fracture zone in the study area. The maximum sediment thickness varied between 7 and 8.5 meters in the Wenner and Schlumberger arrays (1, 2, and 4 m electrode spacing), while the dipole-dipole array indicated a greater sediment thickness ranging from 7.5 to 13 meters. This result was inferred from the difference of resistivity values identified along the profile, as expected a layer of low electrical resistivity (<200 Ωm in the banks and <800 Ωm in the stream bed), overlying higher resistivity layers (>1000 Ωm) in the stream bed and banks. The high resistivity layers were identified as crystalline basement rocks, and low resistivity zones as clayey soil in the superficial part of the stream banks, and sand soil in the stream bed. The presence of sediments and the clearly defined bedrock interface suggest that the site is suitable for constructing an underground dam. However, detecting a potential fracture zone highlights a risk of minor seepage, which should be carefully considered in dam implementation to ensure adequate groundwater storage.

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