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THEORY, PRACTICE AND POLICY

Subsurface Geology of Dambalo Village, Tomilito District, North Gorontalo Regency

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ABSTRACT

Dambalo Village, Tomilito District, North Gorontalo Regency, Gorontalo Province, is the designated research area listed in the administrative records. The main objectives of this research are to determine the surface and subsurface geology, understand the geological conditions of the research area, and analyze the cross-section of subsurface geological layers. The study employs the Schlumberger configuration geoelectric method to examine the subsurface geological cross-section. The researchers used a combination of geological surveys and subsurface data surveys, collecting data on surface geological features, outcrop observations, and resistivity measurements. The research area features a single landform unit, the denudational plain, and its stratigraphy includes a lithostratigraphic unit, Volcanic Breccia. The study area comprises four rock layers: the first layer is topsoil (passive clay), the second layer is sand, the third layer is breccia, and the fourth layer is sand. These conclusions are supported by geological and geoelectric data, demonstrating the effectiveness of integrating surface and subsurface surveys to provide a comprehensive understanding of the geological structure.

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Introduction

Geoelectric methods, a subset of geophysical techniques, investigate the characteristics of electrical currents within the Earth. These methods are used to study subsurface conditions by utilizing the electrical properties of rocks to obtain their resistivity values (Kearey et al., 2002). By passing current through current electrodes into the rock or soil and assuming that the soil acts as a resistor, potential electrodes receive the current. This is how geoelectric methods measure specific resistance.

The research area is located in Dambalo Village, Tomilito District, North Gorontalo Regency. The Wobudu Breccia Formation (Tpwv), composed of volcanic breccia, agglomerate, tuff, lapilli tuff, andesite, and basalt lava, is the rock formation visible on the 1:250,000 scale regional geological map of the Tilamuta sheet. According to Bachri et al.

(1993), "the physical characteristics of volcanic breccia in the field are gray, composed of andesite and basalt fragments ranging in size from gravel to boulder." This formation is significant for understanding the geological history and potential mineral resources of the region.

Based on this description, the researchers conducted a study in Dambalo Village, Tomilito District, North Gorontalo Regency, using the geoelectric method to investigate the properties of Earth's electrical currents and their detection on the Earth's surface. This study aims to provide insights into the subsurface geological conditions, which can have applications in groundwater exploration, mineral prospecting, and geotechnical investigations.

Methodology

The first step in the research process is a review of relevant literature to provide a theoretical foundation and context for the study. The second step involves field data collection, which includes gathering surface geological information such as outcrop observations and rock descriptions. Specific methods used for outcrop observation include detailed mapping and photographic documentation, while rock descriptions involve petrographic analysis and field classification.

The subsurface information is obtained through resistivity measurements taken at three different locations across the study area using the Schlumberger configuration geoelectric method (sounding). The Schlumberger configuration was chosen over other configurations due to its effectiveness in providing deeper penetration and better resolution of subsurface layers, which is crucial for understanding the geological complexity of the research area (Kearey et al., 2002).

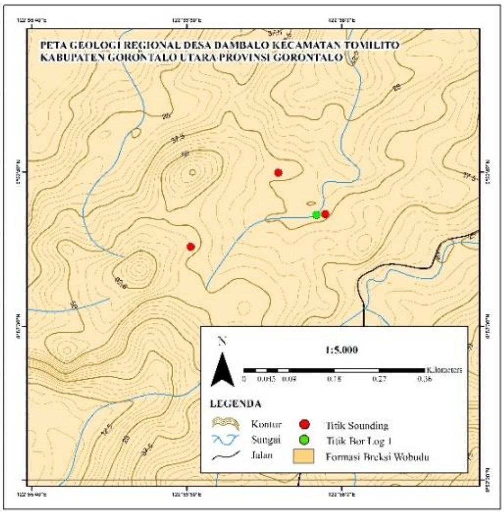
In the third step, the sounding measurement data is analyzed in the studio and input into IPIwin and Progress software to determine resistivity values and create subsurface models from the measurement data. The analysis involves several stages, including data filtering, inversion, and model calibration.

Result

Geology of the Research Area

The research area is part of the Wobudu Breccia Formation (Tpwv), which consists of volcanic breccia, agglomerate, tuff, lapilli tuff, andesite, and basalt lava. According to Bachri et al. (1993), the physical characteristics of volcanic breccia are "gray in color, composed of andesite and basalt fragments ranging in size from gravel to boulder."

Figure 1. Geological Map of the Research Area

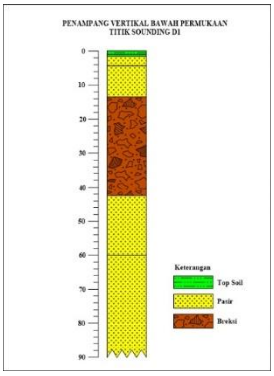


Geoelectric Data Processing

When using Schlumberger configuration geoelectric data in the form of sounding, the potential electrode spacing (MN/2) must be smaller than the current electrode spacing (AB/2) (i.e., MN/2 < 0.2 AB/2). The penetration depth MN/2 is increased by enlarging the current electrode spacing (AB/2), provided MN does not exceed 1/5 of the AB distance if the potential difference is difficult to measure, as this would reduce the sensitivity of the instrument. To determine the apparent resistivity values of subsurface rocks, the quantity of electric current and potential difference at each distance between the current and potential electrodes is measured. Data processing is then performed using Progress software to generate sounding data based on the collected data. The data processing results are presented in the form of a 1D subsurface resistivity cross-section, which is then analyzed considering geological information and resistivity values of the study area.

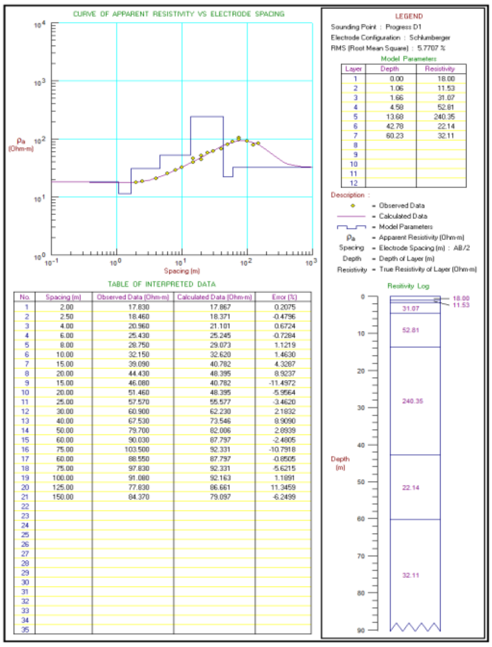
1. Sounding Data D1

Figure 2. Subsurface Resistivity Log Cross-Section at Point D1



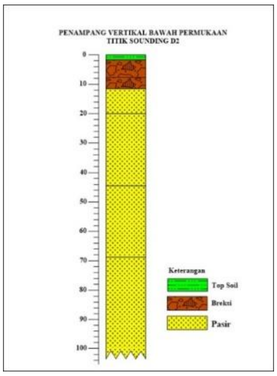
Based on the resistivity log data processing at D1, the inversion results indicate four rock layers. The first layer has a resistivity value of 18.00 – 11.53 Ωm at a depth of 0.00 – 1.66 m, interpreted as topsoil. The second layer has a resistivity value of 31.07 – 52.81 Ωm at a depth of 1.66 – 13.68 m, interpreted as sand. The third layer has a resistivity value of 240.35 Ωm at a depth of 13.68 – 42.78 m, interpreted as breccia. The fourth layer has a resistivity value of 22.14 – 32.11 Ωm at a depth of 42.78 – 60.23 m, interpreted as sand.

Figure 3. Data Processing Results Using Progress Software at Point D1



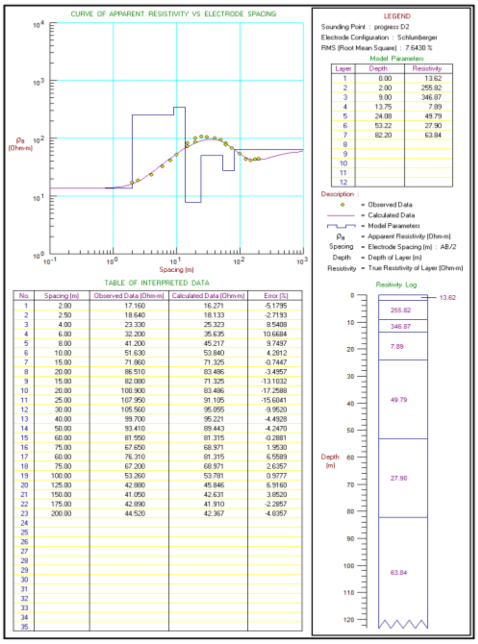
2. Sounding Data D2

Figure 4. Subsurface Resistivity Log Cross-Section at Point D2



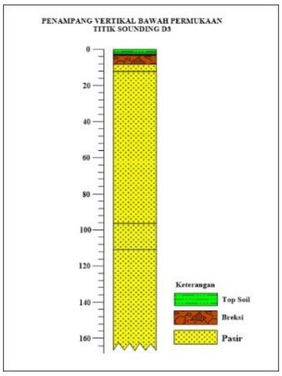
Based on the resistivity log data processing at D2, the inversion results indicate three rock layers. The first layer has a resistivity value of approximately 13.62 Ωm at a depth of 0.00 – 2.00 m, interpreted as topsoil. The second layer has a resistivity value of 255.8 – 346.87 Ωm at a depth of 2.00 – 13.75 m, interpreted as breccia. The third layer has a resistivity value of 7.89 – 63.84 Ωm at a depth of 13.75 – 82.20 m, interpreted as sand.

Figure 5. Data Processing Results Using Progress Software at Point D2



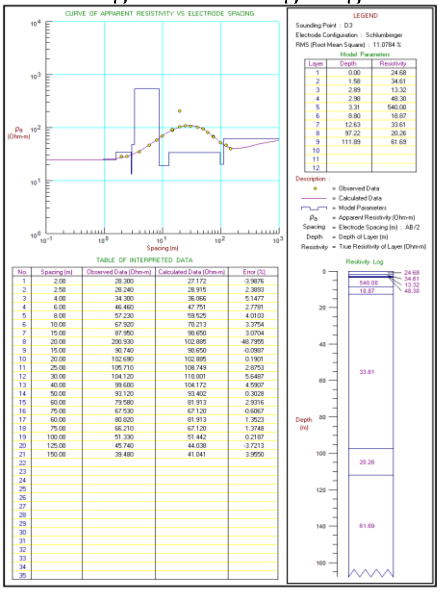
3. Sounding Data D3

Figure 6. Subsurface Resistivity Log Cross-Section at Point D3



Based on the resistivity log data processing at D3, the inversion results indicate four rock layers. The first layer has a resistivity value of 24.68 – 34.61 Ωm at a depth of 0.00 – 2.89 m, interpreted as topsoil. The second layer has a resistivity value of 13.32 – 48.30 Ωm at a depth of 2.89 – 3.31 m, interpreted as sand. The third layer has a resistivity value of 540.00 Ωm at a depth of 3.31 – 8.80 m, interpreted as breccia. The fourth layer has a resistivity value of 18.87 – 61.69 Ωm at a depth of 8.80 – 111.89 m, interpreted as sand.

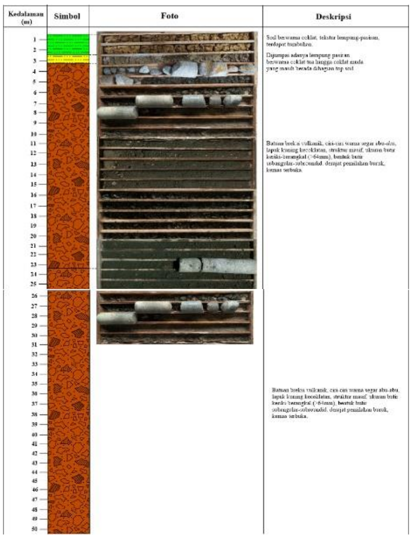
Figure 7. Data Processing Results Using Progress Software at Point D3



4. Drilling Results

Based on the drilling results conducted to a depth of 60 meters, several lithological changes were observed. The initial drilling point from 0 - 2 m encountered topsoil. The second layer at a depth of 2 – 3 m encountered sandy clay, ranging in color from dark brown to light brown, still within the topsoil. The third layer at a depth of 3 – 23.5 m showed a lithological change to volcanic breccia, characterized by fresh gray color, weathered yellowish-brown, massive rock structure, grain size ranging from gravel to cobble (>64 mm), subangular to subrounded grain shape, poorly sorted, and open packing. The fourth layer at a depth of 23.5 – 60 m showed a lithological change to sandstone, characterized by fresh gray color, weathered yellowish-brown, poorly sorted, with grain sizes ranging from fine to coarse sand. A confined aquifer was encountered at a depth of 10 – 13 m.

Figure 8. Vertical Cross-Section of Drilling Results



Discussion

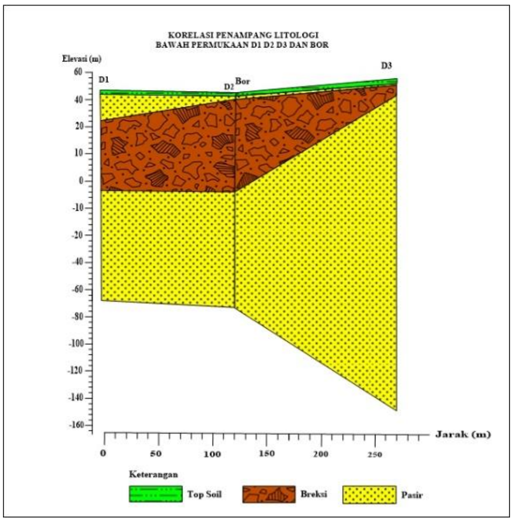
Based on the research results, data analysis, and interpretation using the geoelectric resistivity method and borehole log data, three different types of lithological rock formations were identified in the research area in Dambalo Village, Tomilito District, North Gorontalo Regency. These formations are classified as passive clay, volcanic breccia, and sand.

The interpretation results were then correlated with the subsurface geological cross-sections to determine the continuity of layers based on the resistivity distribution in the research area. The correlation of resistivity data with borehole logs is crucial for validating the geoelectric findings and ensuring accurate subsurface modeling. Resistivity profiles provide a continuous vertical profile of the subsurface, while borehole logs offer precise point-specific lithological information. By combining these two data sources, we can achieve a more comprehensive understanding of the subsurface geology.

For instance, in areas where high resistivity values are recorded, the borehole data confirmed the presence of volcanic breccia, characterized by its dense and non-porous nature. In contrast, lower resistivity values corresponded with layers identified as clay and sand in the borehole logs, which are known for their higher porosity and water content. This correlation allows for the accurate identification and mapping of subsurface layers, enhancing the reliability of the geological model.

From the cross-section analysis, which predominantly shows similar lithology across the profiles, the profile correlation of sounding points D1, D2, D3, and borehole data is illustrated in Figure 9. This figure demonstrates the continuity and extent of the identified lithological layers across different locations in the research area.

Figure 9. Correlation of Subsurface Lithology Cross-Sections at D1, D2, D3 and Borehole Data



The correlation results of the subsurface resistivity cross-sections, along with field observations of the geological conditions of the research area and secondary data (geological map), produce the subsurface cross-section depicted in Figure 9. There is an elevation difference of 3 meters, or about 120 meters, between the sounding locations D1 and D2, which are at altitudes of 45 and 43 meters above sea level, respectively. Although sounding points D2 and D3 are approximately 270 meters apart, they are both at altitudes of 43 and 45 meters above sea level, respectively—a height variation of 13 meters. The drilling began precisely at sounding point 2. The topography of the research area ranges from flat to very steep.

The implications of these findings are significant for understanding the subsurface geology of the area. The identification of passive clay layers suggests potential barriers to groundwater flow, while the volcanic breccia layers could indicate areas of higher structural integrity and stability. The sand layers, with their higher porosity, are likely to be good aquifers, making them important targets for groundwater exploration. This comprehensive geological understanding aids in resource management, environmental assessment, and planning for future geological and geotechnical projects in the region.

Conclusion

Based on the presentation of data processing and analysis results, the conclusions of the research are as follows:

1. Based on the geological survey conducted, it can be concluded that the geomorphology of the research area is a denudational plain. The stratigraphy of the research area consists of volcanic breccia dating from the Late Pliocene to Early Pleistocene, as determined by regional geological correlations and supported by previous studies (Bachri et al., 1993). This age determination is significant as it indicates the region's geological history and potential for resource exploration, such as mineral deposits and groundwater reservoirs.
2. According to the results of the geoelectric lithology survey, the somewhat impermeable layer, whether it is an aquifuge or an aquiclude, envelops the aquifer both above and below. An aquifuge, or crystalline metamorphic rock, is an impermeable layer that cannot store or transmit water. An aquiclude, such as silty clay and fine tuff, is a layer that can hold water but cannot transmit it significantly. Based on the interpretation from the geoelectric cross-section data analysis and borehole log data, the correlation results of the three geoelectric cross-section paths reveal that the same rock layers are present in the borehole log data cross-section in the research area. This correlation enhances the reliability of the subsurface geological model and is critical for identifying potential aquifers and planning resource management strategies.

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