Journal of Open Technologies in Geophysics

RESEARCH ARTICLE

Geoelectric Mapping for Subsurface Bedrock Identification: Implications for Construction Planning at *ITERA*

M. Rafif Pascaloa[1], Made Jnanaparama Aparajita[1], Ahmad Dedi Putra[1], Harish Hartsa Naufal[1] and Putu Pradnya Andika[2]

[1]Department of Geophysical Engineering, Faculty of Science and Technology, University of Jambi, Jambi, Indonesia

[2]Geophysical Engineering, Institut Teknologi Sumatera, Lampung Selatan, Indonesia

***Corresponding Author:**
m.rafifpascaloa@unja.ac.id

Keywords:
Electrical Resistivity,
Wenner-Sclumberger,
Subsurface Mapping

Citation:
Pascaloa, M. R., Aparajita, M. J., Putra, A. D., Naufal, H. H., & Andika, P. P. 2026. Geoelectric Mapping for Subsurface Bedrock Identification: Implications for Construction Planning at ITERA. *Journal of Open Technologies in Geophysics, 2(1), 24-30.*

Received 1 June 2026
Accepted 28 June 2026

Abstract. Sustainable infrastructure development in educational institution areas requires accurate subsurface characterization, particularly in identifying hard rock layers for building foundations. One effective and non-destructive geophysical method for this purpose is the electrical resistivity method. Therefore, geoelectric mapping measurements were carried out along two lines to identify hard-layer distribution within the ITERA campus area. The survey used the *Wenner-Schlumberger* configuration, which provides a balanced lateral and vertical resolution. Each line used 48 electrodes with 4 m spacing and a nominal profile length of approximately 192 m. The processed geoelectric mapping data show variations in subsurface resistivity and indicate a compact tuffaceous sandstone layer within the high-resistivity class (70-200 Ωm), occurring mainly at approximately 8-15 m depth. This distribution of the hard layer is expected to serve as supporting data and recommendations for future physical construction planning and development within the ITERA campus environment.

Abstrak. Pembangunan infrastruktur berkelanjutan di kawasan institusi pendidikan memerlukan karakterisasi bawah permukaan yang akurat, khususnya dalam mengidentifikasi lapisan batuan keras untuk fondasi bangunan. Salah satu metode geofisika yang efektif dan tidak merusak (*non-destructive*) untuk tujuan ini adalah metode resistivitas listrik. Oleh karena itu, pengukuran pemetaan geolistrik dilakukan di sepanjang dua lintasan untuk mengidentifikasi distribusi lapisan keras di dalam kawasan kampus ITERA. Survei ini menggunakan konfigurasi *Wenner-Schlumberger*, yang memberikan resolusi lateral dan vertikal yang seimbang. Setiap lintasan menggunakan 48 elektroda dengan spasi 4 m dan panjang profil nominal sekitar 192 m. Data pemetaan geolistrik yang telah diproses menunjukkan variasi resistivitas bawah permukaan dan mengindikasikan adanya lapisan batu pasir tufaan yang padat dalam kelas resistivitas tinggi (70-200 Ωm), yang terutama berada pada kedalaman sekitar 8–15 m. Distribusi lapisan keras ini diharapkan dapat berfungsi sebagai data pendukung dan rekomendasi untuk perencanaan serta pengembangan konstruksi fisik di masa depan di lingkungan kampus ITERA.

1. Introduction

On October 6, 2014, the President of the Republic of Indonesia officially inaugurated the *Institut Teknologi Sumatera* (*ITERA*) in South Lampung. The establishment of *ITERA* was initiated, developed, and mentored by the *Institut Teknologi Bandung* (*ITB*) with the expectation of achieving equivalent quality. As a relatively new state university with a land area spanning 285 hectares, *ITERA* has demonstrated rapid growth in infrastructure development. During the 2014–2019 period, *ITERA* constructed various facilities, including the General Lecture Building (*GKU*), Engineering Laboratories, administrative office buildings (Buildings A and B), six retention basins (*embung*), a clinic, a mosque, four student dormitories, a faculty housing unit, three lecture buildings (Buildings C, D, and E), sports facilities, and cafeterias. Based on the 2018 *ITERA* master plan, this campus area will continue to undergo extensive infrastructure development in the coming years until the entire spatial plan is fully realized. One of the strategic plans includes the construction of a new *GKU* near the *ITERA* main retention basin area.

Consequently, geotechnical assessment plays a crucial role in identifying hard soil layers to be utilized as building foundations. In regional engineering, morphological factors, soil characteristics, and rock types are the primary aspects that must be considered. Comprehensive planning and spatial management of the development zone are highly necessary to optimize construction outcomes while minimizing the risk of structural failure. Generally, high-rise buildings require firm and stable foundations that rest upon hard rock layers (bedrock) at a specific subsurface depth.

To determine these subsurface conditions, investigation and identification of rock lithology are imperative. Thus far, geotechnical investigations in planned foundation areas have commonly relied on the Standard Penetration Test (SPT), drilling, and cone penetration testing (sondir) (Syamsurizal et al., 2013). However, these methods only provide vertical (one-dimensional) data profiles at specific borehole points. To map the lateral distribution of soil and rock characteristics, the support of geophysical methods is required, one of which is the electrical resistivity method. Based on this urgency, this study applies a geoelectric mapping survey consisting of two survey lines in the main retention basin area of Institut Teknologi Sumatera to identify the subsurface bedrock distribution.

2. Data and Methods

2.1 Study Area

The study area is located within the campus of Institut Teknologi Sumatera (ITERA), situated at Jl. Terusan Ryacudu, Way Huwi, Jati Agung, South Lampung Regency, Lampung Province, Indonesia (Figure 1). The survey was conducted in the vicinity of the main retention basin (embung besar), which is the proposed construction site for a new General Lecture Building (GKU). The survey covered approximately 192 m along each geoelectric transect. Geologically, the study area is part of the Lampung Formation (QTl), as mapped by Mangga et al. (1993) in the Tanjung Karang geological sheet. This formation consists of pyroclastic sedimentary deposits originating from volcanic eruption activities (laharic deposits). The dominant rock type at the study site is tuff (tufa) interbedded with sand layers. The Lampung Formation (QTl) is characterized by lithological units including pumiceous tuff, rhyolitic tuff, welded tuff, tuffaceous mudstone, and tuffaceous sandstone, all of which fall within the Plio-Pleistocene age. The site is structurally flanked by continuity structures trending West-East to the north and Southeast-Southwest to the east and west.

2.2 Geoelectric Resistivity Method

The geoelectric resistivity method is an active geophysical technique that measures the electrical resistivity distribution of subsurface materials by injecting an artificial electrical current through current electrodes (C1 and C2) and measuring the resulting potential difference through potential electrodes (P1 and P2) placed at the surface. The fundamental relationship governing this method is Ohm's Law:

$$V = I.R$$

where V is the voltage (Volt), I is the electric current (Ampere), and R is the resistance (Ohm). Apparent resistivity values are calculated from the measured current and voltage and are subsequently processed to reconstruct a two-dimensional (2-D) model of true subsurface resistivity.

This study employed the *mapping* mode of geoelectric measurement, which aims to characterize lateral resistivity variations at a fixed investigation depth. The electrode configuration adopted in this study was the *Wenner-Schlumberger* configuration, which is a hybrid arrangement combining the advantages of both the Wenner and Schlumberger configurations.

2.3 Data Acquisition

Field measurements were carried out using an ARES multichannel geoelectric resistivity meter. A total of 48 electrodes were deployed along each transect with a uniform electrode spacing of 4 m, producing a nominal profile length of approximately 192 m per line. Two parallel survey lines, Line 1 and Line 2, were measured in the north-south direction and positioned side by side to allow 2-D subsurface imaging. The separation between the two parallel lines enabled cross-line correlation for more robust geological interpretation.

2.4 Data Processing

Raw field data consisting of the measured electric current (I) and potential difference (V) were first imported into Microsoft Excel to compute the apparent resistivity datum for each measurement point along both transects, and subsequently saved in the *.dat* format required by the inversion software. Two-dimensional inversion was then performed using the RES2DINV software, which applies the least-squares (LSQR) algorithm to iteratively minimize the difference between the measured and calculated apparent resistivity pseudosections. This process yields the final 2-D inverse model resistivity section, which represents the true resistivity distribution of the subsurface.

The inversion output from RES2DINV provides three panels: (1) the measured apparent resistivity pseudosection, (2) the calculated apparent resistivity pseudosection derived from the model, and (3) the inverse model resistivity section. To facilitate clearer lithological interpretation, the resistivity color scale was manually adjusted using user-defined contour intervals in RES2DINV, replacing the default logarithmic scale with a linear scale starting from 0 Ωm and increasing in even multiples up to the maximum resistivity value. This adjustment was applied consistently to both Line 1 and Line 2 to ensure comparable color-to-lithology correspondence across transects.

Lithological classification of the inverted resistivity sections was performed by integrating the resistivity values with the regional geology of the ITERA campus area. Based on the lithological units of the Lampung Formation and reference resistivity values from Telford et al. (1990), three resistivity ranges were defined for interpretation, as presented in Table 1. The resulting 2-D resistivity models were then correlated with secondary geotechnical data (N-SPT and machine-drilling logs; Batu Raden, 2014) to validate the interpretation of the subsurface hard layer.

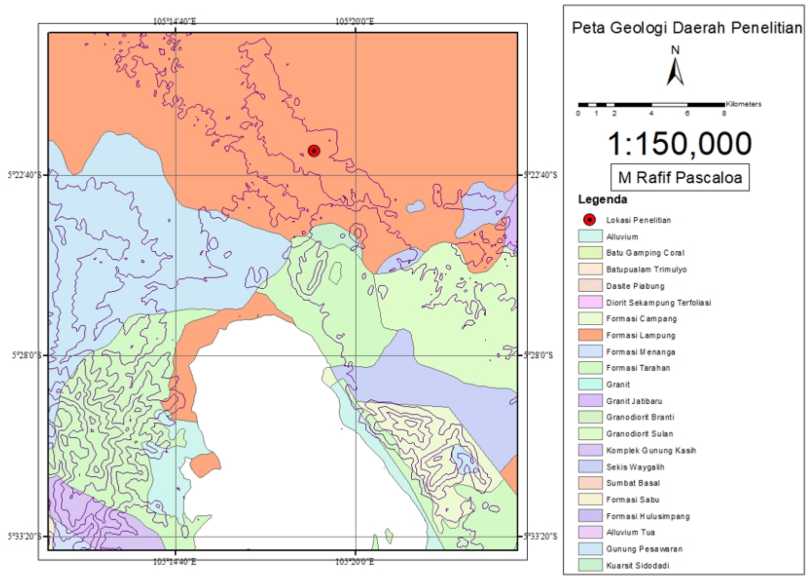

Figure 1. Regional geological map of the research area.

Table 1. Resistivity lithological interpretation for the ITERA campus area, based on Telford et al. (1990)

Resistivity Range (Ωm)	Lithology
<20	Tuffaceous clay (lempung tuffaan)
20–70	Tuff
70–200	Tuffaceous sandstone (pasir tuffaan)

3. Results and Discussion

3.1 Results

The geoelectric resistivity method was successfully applied to characterize the subsurface structure at the study site, emphasizing the potential differences across varying rock resistivities. The measurement was conducted using an ARES multichannel geoelectric instrument with 48 electrodes spaced 4 m apart along a nominal 192 m north-south survey line. To resolve both lateral and vertical subsurface variations effectively, a hybrid Wenner-Schlumberger configuration was utilized consistently on both lines.

a) Line 1: The inversion profile of the first survey line exhibits a distinct high-resistivity zone ranging from 101 to 162 Ωm, identified at a depth of 8-15 m within the lateral distance of 48-68 m from the initial point. This prominent layer is interpreted as a dense and compact coarse-grained tuffaceous sandstone. The high resistivity may reflect compaction, lower water content, and/or cementation rather than lithology alone. At shallower depths (up to 4 m), another high-resistivity zone (72-100 Ωm) is detected at horizontal intervals of 0-64 m and 170-192 m, representing gravelly topsoil or compact fill. This dense, high-resistivity bedrock lies beneath an intermediate-resistivity layer (21-60 Ωm, displayed in dark to light green), which is identified at depths of 1-8 m and classified as a standard tuff layer. Conversely, at deeper zones exceeding 13 m, the resistivity drops continuously to less than 20 Ωm (dark blue zone).

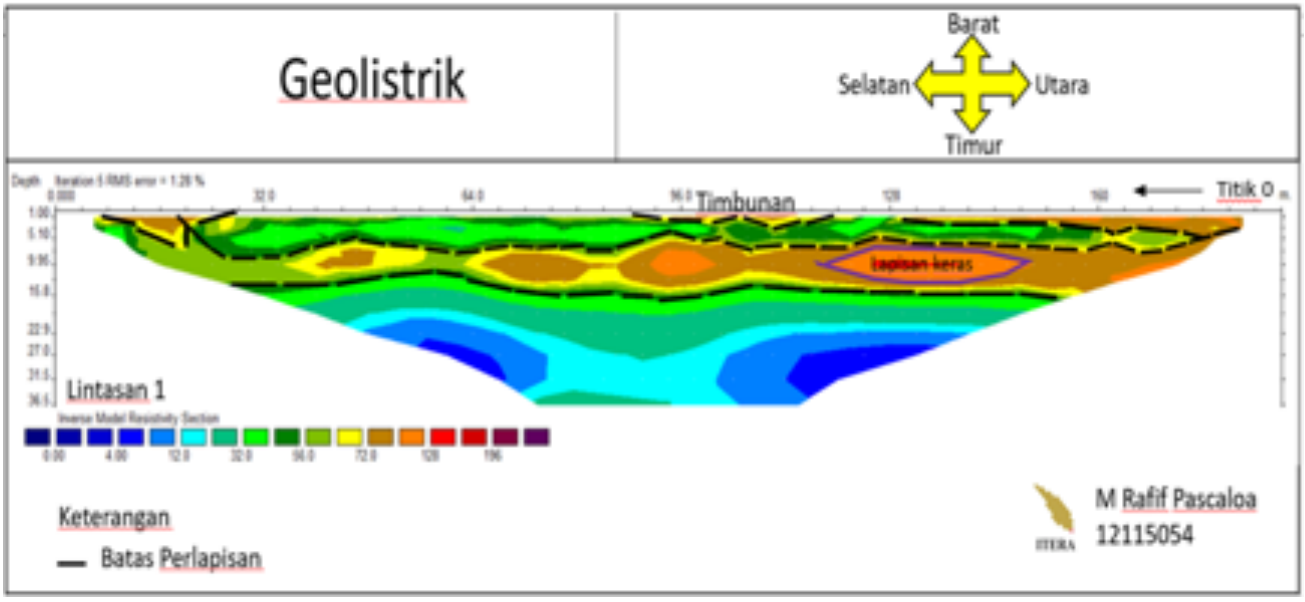

Figure 2. Resistivity 2D section of Line 1.

b) Line 2: Consistent with the first line, the second profile identifies a high-resistivity zone of 72-100 Ωm at a depth of 9-15 m, interpreted as the lateral continuation of the compact tuffaceous sandstone bedrock class. An extremely high resistivity anomaly reaching up to 135 Ωm is also encountered near the surface at a lateral distance of 60-80 m, indicating the presence of gravelly topsoil or compact fill. Similar to Line 1, this bedrock layer is situated underneath a moderate-resistivity unit (21-60 Ωm) characterized as standard tuff. Beyond a depth of 19 m, a drastic decline in resistivity values is observed, reaching less than 20 Ωm (dark blue zone).

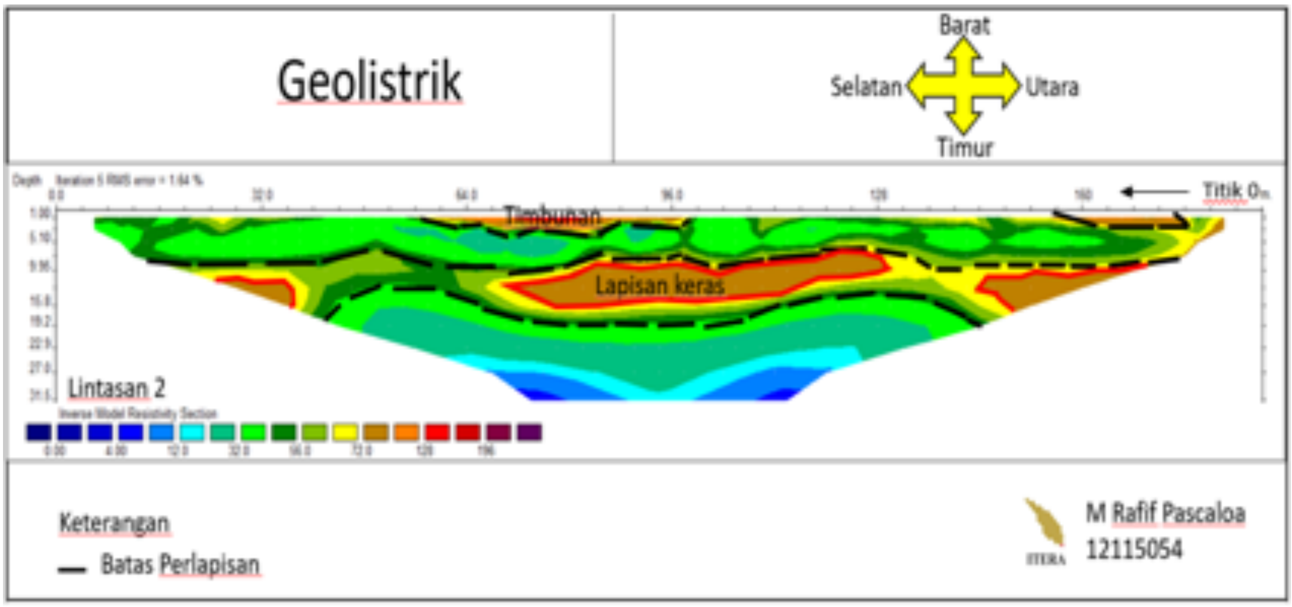

Figure 3. Resistivity 2D section of Line 2.

3.2 Discussion

The 2-D inversion profiles from both geoelectric survey lines reveal a consistent and well-defined subsurface stratification at the study site, providing critical lateral and vertical continuity data for the engineering assessment. The hybrid Wenner-Schlumberger configuration effectively resolved the transition from shallow, unconsolidated topsoil/fill to the deeper, more competent bedrock matrix. On the first line (Line 1), the subsurface model displays a shallow high-resistivity zone ranging from 72 to 100 Ωm down to a depth of 4 m, which corresponds to gravelly topsoil or compact fill. Beneath this material, an intermediate-resistivity layer of 21-60 Ωm is observed at depths of 1-8 m, representing standard volcanic tuff. The primary target of interest on Line 1 is a distinct high-resistivity anomaly of 101-162 Ωm encountered at a depth range of 8-15 m, spanning 48-68 m laterally. This prominent unit is interpreted as compact coarse-grained tuffaceous sandstone, where the elevated resistivity is consistent with a denser fabric and reduced saturation. At greater depths exceeding 13 m, a sharp drop in resistivity to less than 20 Ωm occurs, suggesting a lithological shift towards softer clay-bearing material or a transition into a fluid-saturated zone.

Consistent with the structural trends observed in the first profile, Line 2 identifies the lateral continuation of the compact tuffaceous sandstone bedrock class, characterized by a high-resistivity signature of 72-100 Ωm at a depth range of 9-15 m. Near the surface, specifically at a horizontal distance of 60-80 m, a very high-resistivity pocket reaching up to 135 Ωm is detected, indicating localized gravelly topsoil or compact fill. Similar to Line 1, this bedrock layer on Line 2 is situated beneath a moderate-resistivity tuff layer of 21-60 Ωm. Beyond a depth of 19 m, the deeper regions exhibit a significant decline in resistivity to less than 20 Ωm, reaffirming a clear lithological boundary beneath the competent bedrock layer.

Synthesizing the results of both lines, the targeted hard layer (bedrock) for supporting institutional building foundations is mapped at approximately 8-15 m depth, with the most continuous interval occurring around 9-15 m. The layer belongs to the high-resistivity class of 70-200 Ωm, with local values of 101-162 Ωm on Line 1 and 72-100 Ωm on Line 2. This geoelectric mapping signature is qualitatively consistent with secondary geotechnical indicators of a more consolidated, compact, and dense rock matrix. However, resistivity is also controlled by water content, porosity, clay content, and pore-fluid conductivity. The sharp decline in resistivity at deeper sections highlights how water saturation and/or clay-bearing material can drastically lower the electrical resistance of these volcanic products. Consequently, while geoelectric mapping provides an invaluable non-destructive continuous profile of bedrock distribution, it cannot yet stand alone as a replacement for geotechnical drilling, and structural foundation designs must evaluate potential underlying weak zones to avoid unexpected engineering failures.

4. Conclusions

The subsurface model at the study site consists of several interpreted layers, namely gravelly topsoil or compact fill, volcanic ash-derived tuff, compact tuffaceous sandstone, and low-resistivity clay-bearing tuff or saturated material. The hard layer (bedrock) is interpreted as compact tuffaceous sandstone within the 70-200 Ωm resistivity class. This layer is encountered at approximately 8-15 m depth, with the most laterally continuous competent interval around 9-15 m. It is a potential bearing layer for future building foundations, but final foundation design should still be confirmed using site-specific geotechnical parameters such as N-SPT, drilling logs, groundwater condition, and allowable bearing capacity.

References

Batu Raden, PT. (2014). *Soil Investigation Report: Detailed Engineering Design of Engineering Laboratory 1 and General Lecture Building 1, Institut Teknologi Sumatera Campus*, pp. 7-11.

Mangga, S. A., Amirudin, T., Suwarti, S., Gafoer, S., & Sidarto. (1993). *Geological Map of Indonesia Quadrangle: Tanjungkarang, Sumatra, scale 1:250,000*. Geological Research and Development Centre, Bandung.

Syamsurizal, Cari, & Darsono. (2013). *Aplikasi Metode Resistivitas untuk Identifikasi Litologi Batuan Sebagai Studi Awal Kegiatan Pembangunan Pondasi Gedung*. Indonesian Journal of Applied Physics, 3(1), 99-106.

Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). *Applied Geophysics* (2nd ed.). Cambridge University Press. https://doi.org/10.1017/CBO9781139167932