

syad\_2019\_IOP\_Conf.\_Ser.\_Earth\_Environ.\_Sci.\_279\_012039.pdf

f

*by*

---

**Submission date:** 05-Dec-2021 08:24PM (UTC+0700)

**Submission ID:** 1720959930

**File name:** syad\_2019\_IOP\_Conf.\_Ser.\_Earth\_Environ.\_Sci.\_279\_012039.pdf (1.16M)

**Word count:** 2073

**Character count:** 11545

PAPER · OPEN ACCESS

## Reconstructing past landslide models based on subsurface resistivity profiles: case study from Majene West Sulawesi

To cite this article: Ardy Arsyad *et al* 2019 <sup>4</sup> *IOP Conf. Ser.: Earth Environ. Sci.* **279** 012039

View the [article online](#) for updates and enhancements.



The banner features a decorative top border with a repeating pattern of colored diagonal lines. On the left, the ECS logo is displayed in a green circle. To its right, the text reads "The Electrochemical Society" followed by the tagline "Advancing solid state & electrochemical science & technology". The main event information is presented in large, bold letters: "240th ECS Meeting" in black, "ORLANDO, FL" in blue, "Orange County Convention Center" in orange, and "Oct 10-14, 2021" in black. On the right side, there is a photograph of a crowd of people. At the bottom, an orange bar contains the text "Abstract submission due: April 9" and a blue bar contains the text "SUBMIT NOW".

**ECS** The Electrochemical Society  
Advancing solid state & electrochemical science & technology

**240th ECS Meeting** ORLANDO, FL  
Orange County Convention Center Oct 10-14, 2021

Abstract submission due: April 9 **SUBMIT NOW**

## Reconstructing past landslide models based on subsurface resistivity profiles: case study from Majene West Sulawesi

Ardy Arsyad<sup>1</sup>, Sabrianto Aswad<sup>2</sup>, Erfan Syamsuddin<sup>2</sup>

<sup>1</sup>Department of Civil Engineering, Faculty of Engineering, Hasanuddin University  
Makassar Indonesia

<sup>2</sup>Study Program of Geophysics, Faculty of Mathematics and Natural Science,  
Hasanuddin University, Makassar, Indonesia

[ardy.arsyad@unhas.ac.id](mailto:ardy.arsyad@unhas.ac.id)

**Abstract.** This paper presents a case study of reconstructing past landslide failure models in a napal geological formation by undertaking a series of geoelectrical tomographies and geotechnical bor-SPT surveys. Study area is located in the National Artery Road 135 Kilometres, Majene – Mamuju, West Sulawesi. Geological formation found in the area is Napal Pambauang Formation. Massive ground movement is obviously detected in the area, and several landslide events have been occurred in the last 10 years. In order to derive an effective technique of mitigating the landslide in the area, past landslide failure models are needed to reconstruct. Therefore, 2D geoelectric tomographies survey combined several geotechnical bors were undertaken. A Framework of geophysics and geotechnical investigations was developed and implemented. The results show that slope failure models can be mapped, following unique patterns in the subsurface resistivity models. The finding slope failure models are well agreement with successive scarp patterns founded in the slope area. Past and recent landslides and future landslide are derived and this can be employed to design effective landslide mitigation strategies.

Keywords: past landslide, electrical resistivity tomography, slip failure plane, reconstructing



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Published under licence by IOP Publishing Ltd

## 1. Introduction

Landslides have become the second of the common natural disaster in Indonesia after flood disaster. Landslides and floods events comprise 18% and 32% of the total natural disaster events, recorded since 1815 [1]. In 2018, landslide events have been accounted for at least 1142 events throughout Indonesia. Therefore, recent landslide disaster mitigation techniques have been developed since significant economic losses and even fatalities caused by this disasters. Current studies on detection and investigation techniques of old landslide have been conducted due to most landslide events in many regions are in some cases as a result from reactivation of old landslides. Bell et al. [2] performed old landslide study for the case of Swabian Alb Germany. New and old landslide body structures were identified by using 2D electrical resistivity tomography (ERT), while their moisture distributions were monitored. The use of 2D ERT is widely applied, how to apply this geophysical method for geomorphology can be explored in Schrott et al. [3]. Other method such ground penetrating radar (GPR) is just suitable for shallow small scale landslide, due to its drawback of damping by soft sediment and reflecting by woody material [4]. By considering that conventional techniques such as drillings (Bor-SPT) can provide point information of slope stratigraphy, while 2D ERT can derive continuous profile of slope stratigraphy [5] [6], it is necessary to combine those techniques to obtain the most reliable of landslide models. In the case of Swabian Alb [2] [4], the sliding plane and lateral boundary can be detected clearly. Therefore, this paper aims to present the use of geophysical and geotechnical techniques in investigation old landslide body structures in the case of Majene Tanjung Rangas West Sulawesi. Geophysical survey of ERT and geotechnical drilling and penetrating tests were undertaken on that slope area.

## 2. Site Characteristics

### 2.1. Geological setting

The landslide area is situated on Tanjung Rangas Majene, National Artery Road Km. 135, West Sulawesi (Figure 1). Geologically, the area (Figure 2) is on the Pleistocene Napal Pambuang which deposits Tuffaceous marl, marly shales, tuffaceous sandstone, and lenses of conglomerate [7]. The Pambuang Marl is about 300 m thick, formed in a shallow marine environment. This formation crops out in the South-West corner of Majene Regency. General stratigraphy of this area is represented by a marly shales and tuffaceous sandstone, which is overlain by Tuffaceous marl (Figure 3). Marl is calcium carbonate rock which is dominated by clay and silt. Originally, marl was formed as mixtured between clay and calcium carbonate. The marl is found to containing nodules.



Figure 1. Location of the landslide area.



**Figure 2.** Geological Map of the landslide area (Qpps = Napal Pambuang, Tmm = Formation of Mandar, Tmpm = Formation of Mapi).



**Figure 3.** Stratigraphy of the rock formation in the landslide area.

## 2.2. Borehole Data

Geotechnical investigations were undertaken in the landslide area. Four boreholes were drilled over the landslide materials and the surrounding areas (Figure 4). The depth range of the boreholes is about 40 m, except for BH 2, which is just 30 m. Figure 5 show the depth of groundwater is at 15 m below the ground of road level, whereas the thickness of landslide material varies from 5 m to 7 m. This can be seen in the stratigraphy based on BH 1 - BH 2 (Figure 5) and BH 3 - BH 1 - BH 4 (Figure 6). The landslide material was underlaid by stiff clay and napal. It is obvious that the soft clay and stiff clay indicate the weathering of napal. At 5 m below the ground, the napal is heavily weathered due to the fluctuating groundwater level in this depth.



Figure 4. Layout of the boreholes location in the landslide area and the environment.

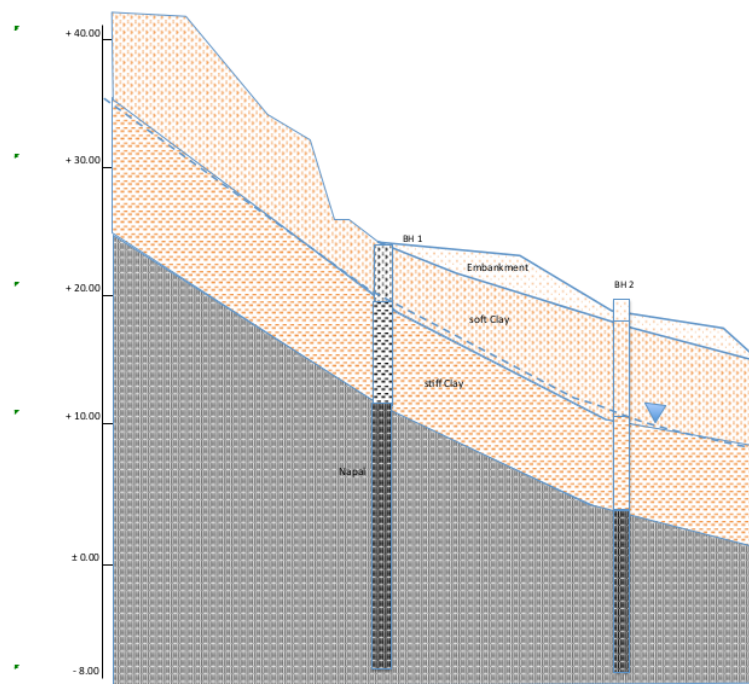
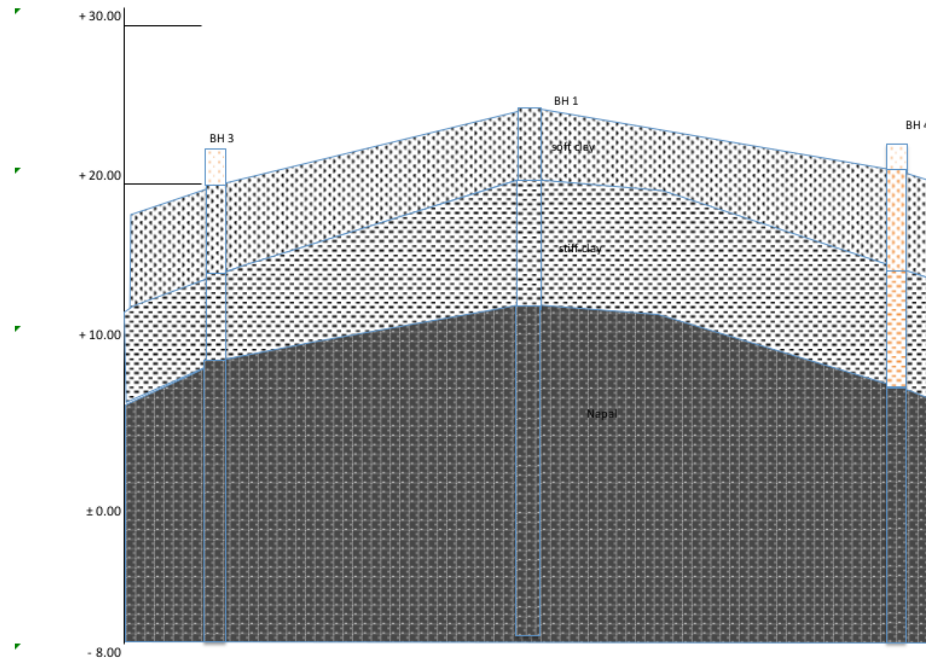


Figure 5. Estimated stratigraphy derived from BH 1 – BH 2, where are situated parallel to landslide movement.



**Figure 6.** Estimated stratigraphy derived from BH 3 – BH 1 – BH 4, where are situated perpendicular to landslide movement.

### 3. 2D Electrical Resistivity Tomography Survey

A 2D ERT survey was undertaken in order to measure resistivity distribution in below the ground of the landslide area. The survey measured the electrical potential between a pair of electrodes due to direct injection between another pair of electrodes. After that, apparent resistivity is measured. In this study, two-dimensional ERT was performed within a multi electrode cable, arranged in three lines including Line-1, Line-2 and Line-3 (Figure 7). Data were acquired by a Wenner-Schlumberger configuration using a 60-electrode cable 5 m apart. RES2DINV software was employed to process the data for a 2D tomographic inversion technique based on the smoothness-constrained least squares inversion of pseudosection data [8], and the calculated pseudosection based on finite difference method [9].

### 4. Results

Figure 8, 9 and 10 show the results of electrical resistivity tomography with the simplified logs of the boreholes. The data along Lines-1 was measured in parallel, while Line -2 and -3 were measured in perpendicular directions to the landslide movement. The resulting tomogram along this profile

suggests contrast resistivity values from low to high resistivity. Figure 8 illustrates that there are four distinct contrast resistivity zones along the line, indicating four slip planes in the landslide areas. In addition, landslide material such as full saturated soft clay, stiff clay and napal observed in the boreholes are in good agreement with the result of ERT. For instance, Figure 9 and 10 show low resistivity area which has similar profile to soil layers shown in the stratigraphy of BH 3 – BH 1 – BH4 as illustrated in Figure 6. Profound results in this study based on ERT profiles reveal several events of landslide have been occurred, from the oldest to the youngest landslide. The mechanism of such grand landslide can be seen in the oldest landslide in Figure 8. After the movement of this oldest landslide, small landslides occurred sequentially from old to very young landslide. Future landslide can be predicted at the potential slip failure between the oldest landslide and the very young landslide. The ERT profile is well agreement with the existing landslide scarps found the field (Figure 11).



Figure 7. layout of ERT Line measurements.

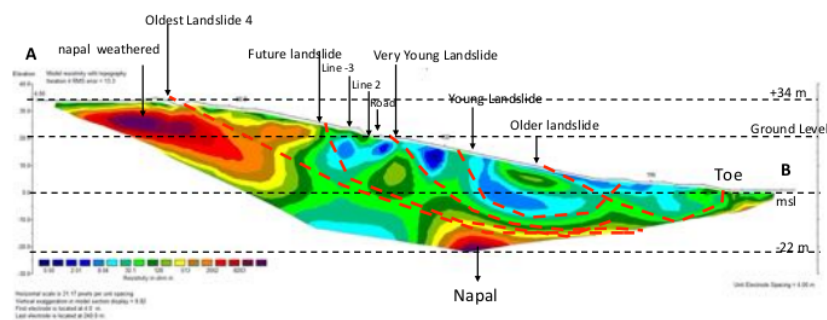


Figure 8. Resistivity modelling of the landslide area through Line 1.

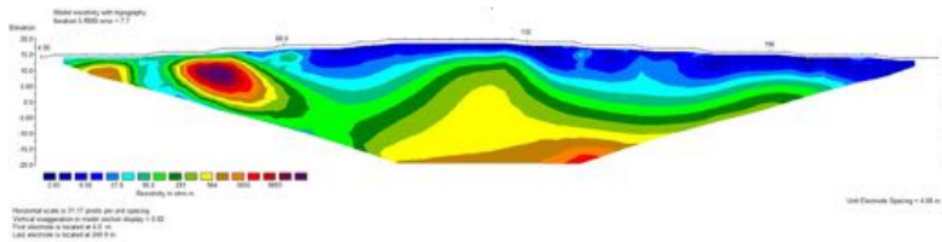


Figure 9. Resistivity modelling of the landslide area through Line 2.

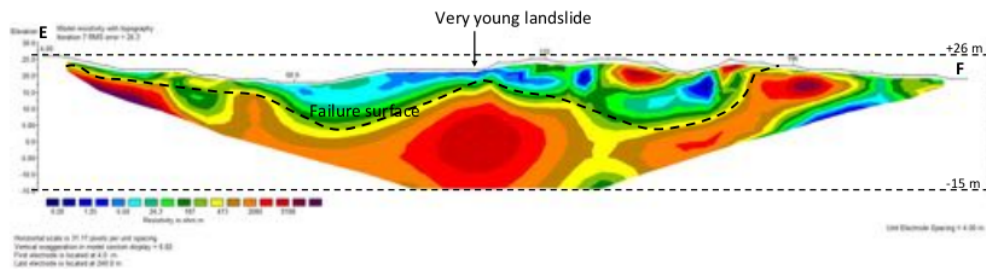


Figure 10. Resistivity modelling of the landslide area through Line 3.



Figure 11. Existing landslide scarps in the landslide areas indicates periodical events of landslide have occurred.

## 5. Conclusions

This study presents case of study of reconstructing the mechanism of sequential landslide models that took place in the Tanjung Rangas Majene West Sulawesi. The results suggested that the electrical resistivity tomography is a useful technique for investigation of past landslides. The ERT could be employed to determine geometry and water saturated zones in landslide areas, as well as mapping the location of slip failure planes, which can be used to reconstruct the sequential of landslide events occurred in the past. The ERT profiles have been confirmed well with the boreholes. For the case study, it was found that landslide materials are around 5 m to 7 m thick below the ground and at least five slip failure planes. The results suggested that landslides have been taking place in many times for five periods. A future landslide located in between the oldest landslide and the recent landslide would predictably occur if the prevention measures could not be immediately undertaken.

## 6. References

- [1] BNPB 2018, Data Kejadian Bencana Longsor, Badan Nasional Penanggulangan Bencana, Jakarta.
- [2] Bell, R., Kruse, J-E., Garcia, A., Bonn, Hordt, A., Brauschweig, 2006 Subsurface investigations of landslides using geophysical methods geoelectrical applications in the Swabian Alb (Germany), *Subsurface Landslide Investigation*, pp. 201-208.
- [3] Schrott, L., Hördt, A. & R. Dikau (eds) 2003 Geophysical applications in geomorphology. - *Zeitschrift für Geomorphologie, Supplementband 132*, Berlin, Stuttgart: Gebrüder Borntraeger.
- [4] Sass, O., Bell, R., Glade, T, 2008. Comparison of GPR, 2D-resistivity and traditional techniques for the subsurface exploration of the Öschingen landslide, Swabian Alb (Germany), *Geomorphology*, 93, pp. 89-103.
- [5] Drahor, M., Berge, M., Gorktukler, G., Kurtumulus, T.O., 2006. Application of electrical resistivity tomography technique for investigation of landslides: A case from Turkey. *Environmental Geology*, vol 50, pp. 147-155.
- [6] Perrone, A., Lapenna, V., Piscitelli, S. 2014. Electrical resistivity tomography technique for landslide investigation: A review. *Earth Science Review* 135, pp. 65-82.
- [7] Djuri, Sudjarmiko, Bahri, S., Sukido, 1998. Peta Geologi Lembar Majene dan Lembar Bagian Barat Palopo, Pusat Penelitian dan Pengembangan Geologi, Bandung.
- [8] Loke MH, Barker RD 1996 Rapid least- squares inversion of apparent resistivity pseudosections using a quasi-Newton.
- [9] Dey A, Morrison HF 1979 Resistivity modelling for arbitrarily shaped two- dimensional structures. *Geophys Pros- pect* 27:106–136

ORIGINALITY REPORT

11%

SIMILARITY INDEX

10%

INTERNET SOURCES

7%

PUBLICATIONS

6%

STUDENT PAPERS

PRIMARY SOURCES

|   |  |     |
|---|--|-----|
| 1 | <a href="http://hdl.handle.net">hdl.handle.net</a><br>Internet Source  | 3%  |
| 2 | Submitted to Unizin, LLC<br>Student Paper  | 3%  |
| 3 | <a href="http://link.springer.com">link.springer.com</a><br>Internet Source  | 2%  |
| 4 | Submitted to University of Lancaster<br>Student Paper  | 1%  |
| 5 | Nart Coşkun, Özcan Çakır, Murat Erduran, Yusuf Arif Kutlu, Ziya Sedat Çetiner. "A potential landslide area investigated by 2.5D electrical resistivity tomography: case study from Çanakkale, Turkey", Arabian Journal of Geosciences, 2015<br>Publication | 1%  |
| 6 | <a href="http://cjees.ro">cjees.ro</a><br>Internet Source  | 1%  |
| 7 | <a href="http://www.scirp.org">www.scirp.org</a><br>Internet Source  | <1% |

8

"Advancing Culture of Living with Landslides",  
Springer Nature, 2017

Publication

<1 %

9

Mahmut G. Drahor, Gökhan Göktürkler, Meriç  
A. Berge, T. Özgür Kurtulmuş. "Application of  
electrical resistivity tomography technique for  
investigation of landslides: a case from  
Turkey", Environmental Geology, 2006

Publication

<1 %

10

[jurnal.uns.ac.id](http://jurnal.uns.ac.id)

Internet Source

<1 %

Exclude quotes  On

Exclude bibliography  On

Exclude matches  < 5 words