The Identification of Krakatoa Tsunami Deposits Based on Comparison of Geological and Electrical Resistivity Tomography Method, in Kunjir, South Lampung

Rizka1*, Rahmat Fadhilah2, Beta Arroma Piskora1, Arvico Putraloka1, Aviv Alansyah1, Kris Hamonongan Parulian David1

1 Geophysical Engineering, Institut Teknologi Sumatera, Lampung, Indonesia
2 Mining Engineering, Institut Teknologi Sumatera, Lampung, Indonesia

*rizka@tg.itera.ac.id

Abstract. The research location is located in Kunjir Village, Rajabasa District, South Lampung. This village is an area that was affected by the tsunami waves due to the eruption of Mount Krakatau in 1883 and the village worst affected by the Krakatoa tsunami on 22 December 2018 in Lampung. This research was conducted to determine tsunami deposits using geoelectrical methods which are correlated with stratigraphic observations and thin section petrographic analysis on river walls in the study area. The geoelectrical method used is Electrical Resistivity Tomography (ERT). The ERT survey was carried out on 1 line located near the river. The purpose of the ERT survey is to determine tsunami deposits. Based on geological observations, it is suspected that there is a tsunami deposit in the form of a layer of sand mixed with pyroclastic and pumice rocks. Based on thin section petrographic analysis, it tends to show a pattern of changes in composition upward following changes in grain size. Based on the pseudo-section of the result of Electrical Resistivity Tomography processing, it is suspected that tsunami deposits were found in sandstone with a resistivity value of 17 - 100 Ωm.

Keywords : Electrical Resistivity Tomography, tsunami deposits, Krakatoa, Kunjir

1. Introduction

Research on tsunami deposits resulting from volcanic eruptions is still limited because tsunami events due to volcanic eruptions are rare. It is noted from the author, that geological research on the characteristics of tsunami deposits has been carried out in Lampung by [1] around the Semangko Bay coast and [2] around Tarahan, Lampung. The impact of the tsunami due to volcanic eruptions has had a major impact, such as the 1883 and 2018 Krakatoa tsunami. The 1883 and 2018 Krakatoa tsunami incurred many casualties and resulted in heavy infrastructure damage in Lampung. The area worst affected by the 2018 Krakatoa tsunami in Lampung was Kunjir. Limited information regarding subsurface geological conditions, especially after the 2018 tsunami in Kunjir, can be an obstacle in accelerating the revitalization of physical infrastructure development. Therefore, it is necessary to study the subsurface geological conditions in Kunjir. The method that can obtain subsurface geological information is the geoelectrical method.

Research on tsunami deposits can also be carried out using geo-electric methods as has been done previously by [3] investigating ancient rivers in Banda Aceh, and [4] identifying paleo tsunamis in Aceh Besar. Based on the knowledge of the state of arts and there has never been any research on the Krakatoa tsunami deposits in Kunjir, so the authors researched in Kunjir. The study was conducted to determine sediment deposits using...
geoelectrical methods (Electrical Resistivity Tomography (ERT)) which correlated with geological data, namely thin-section petrographic analysis. This research is expected to obtain subsurface geological information and become a preliminary study to determine the Krakatoa paleo-tsunami in Kunjir which is useful for determining the age of the Krakatoa tsunami.

2. Method

2.1 Tsunami Deposits

Tsunamis can be deposited as layers whose number of layers depends not only on the number of waves but also on the morphological setting, the level of deposition compared to the mean sea level, and the distance from the coastline. Tsunami wave height is defined as the distance between the mean tidal level and the highest level of tsunami inundation. Tsunami height or flow depth is determined as the depth of water from the ground to the crest of the tsunami wave (at the shore) [5]. Tsunami waves changed the current geomorphology by eroding some areas and accumulating sediment. The sources of these deposits vary in that marine sediments can be eroded on exposure or directly onshore at landing, and terrigenous sediments can be seaward [6]. Most of the sediment is deposited on land, while offshore sediment is rare but possible due to debris or turbidity flows such as by tsunami backflow.

2.2. Regional Geology

The research was performed in Kunjir, which is located at the foot of Mount Rajabasa in the south. Basis of the analysis of topographic maps at a scale of 1: 50,000 Sheet 1110 by the National Coordinating Agency for Surveys and Mapping [7], rivers in the study area have radial flow patterns. This flow pattern is controlled by topography in the form of heights (volcanic cones). These rivers flow from the high topographical area, namely the peak of Mount Rajabasa, and down the slopes of the mountain to the foot of the mountain. Meanwhile, stratigraphy according to the Geological Map of the Cape Karang Sheet, Sumatra [8], the areas of Kunjir are included in the Rajabasa Young Volcano Sediment (Qhv (rb)). This unit consists of andesite to basalt lava, breccias, and tuff that are Quaternary in age.

2.3. Electrical Resistivity Tomography (ERT) Methods

The Electrical Resistivity Tomography (ERT) method is a geo-electric resistivity method which is carried out by injecting an electric current under the surface of the earth to obtain a resistivity pseudo section or a model of the distribution of the resistivity value of the subsurface material laterally and vertically [9]. Based on the statement [10] that the ERT method can map the sedimentation layer and evaluate differences in geological boundaries on shallow surfaces. In this study, 1 line of ERT measurements was carried out using the Naniura instrument with 4 electrodes in the Wenner Alpha configuration. The electrode configuration used in ERT measurements is Wenner Alpha. The Wenner Alpha configuration has two current electrodes (C2 - C1) and the same potential electrode (P2 - P1), namely a, wherein this measurement the distance between the electrodes is 0.5 m. The ERT track length is 15 m with a penetration of 1.7 m. The design of the ERT measurement acquisition can be seen in Figure 1.
3. Results and Discussions

Based on the geological observations in Figure 2, it was found that tsunami deposits were in the form of a layer of sand mixed with igneous volcanic rocks and pumice rocks at a depth of 30-70 cm and 13-170 cm. At this location, no marine organisms were found. However, in the tsunami sediment, the absence of marine organisms is not an absolute matter because the material of these organisms is easily dissolved and not preserved. The presence of pumice as fragments indicates that this sand layer is the result of a tsunami due to a tsunami volcanic eruption [2]. Igneous volcanic rocks and pumice rock deposits are volcanic deposits that have been carried away by the tsunami.

In view of this Table 1, found in the sand layer found lithic (55%), opaque (5%), quartz (5%), feldspar (20%), clay mineral (15%). In the igneous volcanic rocks layer which has a basalt-andesite base mass found plagioclase (40%), sanidine (10%), olivine (20%), Lithic and mineral accessories in the form of glass (15%), quartz (5%), and hornblende (20%). Proceeding from this Table 1, it can be analyzed that heavy minerals tend to show a pattern of changes in composition upward following changes in grain size.
Table 1. Petrographic analysis of thin sections

| Layer | Name of Rocks                  | Depth      | Descriptions                                                                                                                                 |
|-------|--------------------------------|------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | Top Soil                       | 0 – 30 cm  | Brownish gray color, medium texture clastic, the grain size of clay - fine sand (<0.001-0.125mm) medium sorting, lithic composition |
|       | Sedimentary Rocks              | 30 – 70 cm | (hornblende, plagioclase, pyroxene), opaque, quartz, feldspar, mineral clay.                                                                    |
| 2     | Sedimentary Rocks (Sandstone)  | 70 – 120 cm| Greenish, yellow, and colorless, the base mass is affanitic (<0.1mm-glass), anhedral-subhedral mineral form, phenocryst (0.01-0.25mm) in  |
| 3     | Igneous Volcanic Rocks         | 120 - 130 cm| the form of plagioclase, sanidine, olivine and other accessory minerals, glass, quartz, and hornblende.                                         |
| 5     | Sedimentary Rocks (Sandstone)  | 130 – 170 cm| Brownish gray color, medium texture clastic, the grain size of clay - fine sand (<0.001-0.125mm) medium sorting, lithic composition (hornblende, plagioclase, pyroxene), opaque, quartz, feldspar, mineral clay. |
| 4     | Sedimentary Rocks (Mudrock (Clay)| 120 - 130 cm| There is a massive structure, the texture includes clay grain size (<0.001mm), closed packaging, half-angled round grain shape, and good sorting. It consists of quartz and is dominated by silica clay minerals |

According to the processing of Electrical Resistivity Tomography (Figure 3), it is found that geological features consist of topsoil, sand, clay, and igneous volcanic rocks. It found a resistivity value of <4 Ωm which is clay, 4 - 17 Ωm which is the topsoil, 17 - 100 Ωm which is sand, and > 100 Ωm which is a igneous volcanic rocks. Tsunami deposits are thought to be in a layer of sand.
4. Conclusion

It has been found that rocks suspected of tsunami deposits in Kunjir are a layer of sand mixed with pyroclastic and pumice rocks at a depth of 30-70 cm and 130-170 cm. The presence of pumice as fragments indicates that this sand layer is the result of a tsunami due to the tsunami volcanic eruption. Pyroclastic and pumice rock deposits are pyroclastic deposits that have been carried away by the tsunami. Based on the pseudo-section of the result of Electrical Resistivity Tomography processing, the suspected tsunami deposits were found in sandstone with a resistivity value of 17 - 100 Ωm.

5. Acknowledgements

We want to thank the Director of Research and Community Service, Ministry of Research and Technology / National Research and Innovation Agency with contract number 009/SP2H/LT/DRPM/2020 for providing the funding for this research. Also to Lab Geophysics for the resistivity instrument to acquire the data.

References

[1] Putra P S and Yulianto E, 2016 Stratigrafi Endapan Tsunami Krakatau 1883 di Daerah Limus, Pantai Barat Teluk Semangko, Lampung J. Lingkung. dan Bencana Geol. 7, 1 p. 35–44.
[2] Putra P S and Yulianto E, 2017 Karakteristik Endapan Tsunami Krakatau 1883 Di Daerah Tarahan, Lampung Ris. Geol. dan Pertamb. 27, 1 p. 83.
[3] Zainal M Yanis M Umar M and Ismail N, 2017 Investigation of Shallow Paleochannel in Banda Aceh based on Electrical Resistivity Tomography J. Aceh Phys. Soc. 6, 1 p. 1–5.
[4] Syukri M Saad R Anda S T and Fadhli Z, 2019 Resistivity and Chargeability Signatures of Tsunami Deposits At Aceh Besar and Banda Aceh Coastal Area, Indonesia Int. J. GEOMATE 17, 59 p. 133–143.
[5] Koster B Reichert K Vött A and Grützner C, 2011 The Evidence of Tsunamigenic Deposits in the Gulf of Corinth (Greece) With Geophysical Methods for Spatial Distribution in 2nd INQUA-IGCP-567 International Workshop on Active Tectonics, Earthquake Geology, Archaeology and Engineering p. 107–110.
[6] Dawson A G and Stewart I, 2007 Tsunami deposits in the geological record Sediment. Geol. 200, 3–4 p. 166–183.
[7] Bakosurtanal, 1993 Lampung.
[8] Mangga S A Amiruddin Suwarti T Gafoer S and Sidarto, 1993, Geologi Lembar Tanjung Karang, Sumatera.
[9] Lowrie W, 2007 Fundamentals of Geophysics.
[10] Giocoli A Magri C Vannoli P Piscitelli S and Rizzo E, 2009 Electrical Resistivity Tomography investigations in the Ufita Valley (Southern Italy) Ann. Geophys. 51, February 2008 p. 213–223.