Morphotectonic of volcanic area in Rawa Danau, Banten Province

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Abstract. Rawa Danau is a caldera and considered as an inactive volcano. Based on landscape characteristic the morphology was influenced from volcanic processes. However, many geological structures such as fractures were also found. Our research is trying to understand that the landscape in the Rawa Danau area whether it was controlled by tectonic activity or only by volcanic activity. The analysis of this study compared three different data: ridge linearity and river linearity that were obtained from analysis of satellite imagery. All the data then be compared with the fracture azimuth data obtained through field surveys. The three data were compared with each other by statistical analysis (Mann-Whitney U test), to test the relationship between the three. Based on the data analysis that has been carried out, it can be seen the results of the statistical analysis shows the average difference between the two independent samples, it shows that the area's landscape is controlled by the volcanic process.

Keywords: Rawa danau, morphotectonic, statistical analysis

1. Introduction

Banten is one of the regions affected by subduction zones in the South of Java and became strongly influenced by an active tectonic [1]. Based on the regional sheet of geological map of Anyer, Banten, especially in the Rawa Danau area, there were many geological structures that became markers of the deformation process, besides there are also many volcanoes that are inactive and some of that formed a caldera [2]. In the study area, there is a large caldera which is now filled with water and transformed into swamps and lakes. This is where the local get the name of this place as Rawa Danau. The morphology of the research area is varied from lowlands to mountains [1]. The study area was composed of volcanic rocks of Late Pliocene-Late Holocene. Due to its relatively young age, the constituent rocks of the study area are quite weathered and the secondary geological structures that are formed are quite difficult to find and identify [3]. To analyze tectonic activity in the study area we used morphometric analysis which is the linearity ridge and river measurements [4]. In addition, field activities were also conducted which were intended to obtain fracture azimuth data caused by tectonic processes [5, 6]. Based on the characteristics of the landscape, the morphology of the study area is influenced by volcanic processes. However, many geological structures such as fault and fractures are also found which indicate tectonic activity [2, 3]. From the data that can arise a hypothesis or statistical statement about the parameters of the population, but to prove the validity of the hypothesis it is necessary to do statistical tests with divide hypothesis became two, that is Ho and H1:
Ho = The landscape of Rawa Danau is influenced by tectonic activity in its formation.

H₁ = The landscape of Rawa Danau is not influenced by tectonic activity in its formation.

This research tried to understand that the landscape in the Rawa Danau area whether is controlled by tectonic activity or volcanic activity only. Morphotectonic research is useful to determine how influential tectonic activity occurs in the study area and is useful also to analyze the level of disaster that might occur in the area.

2. Data and method
Analysis of this study compares three different data using statistical analysis; ridge linearity, river linearity, and fracture azimuth data to understand the relationship between the three. Linearity data was obtained through straight-line drawings that present the direction of the ridge and river, this analysis used Digital Elevation Model (DEM) SRTM data from https://vertex.daac.asf.alaska.edu/# with resolution 1:50,000 and data which was processed using ArcGIS 10.2.1® [7, 8]. Fracture azimuth data was obtained through field surveys and measured using a geological compass. Then performed statistical analysis using Microsoft Excel 365® and IBM SPSS Statistics 25® to understand the relationship between the three data. Statistical analysis begins with a normality test to see whether the three data are normally distributed or not, in this study normality test was used using the Liliefors method. Liliefors method is a statistical analysis to see data are normally distributed or not, and in this study used alpha value of 0.05. If the data was normally distributed then a parametric statistical analysis is performed, namely the homogeneity test (F test) and t-test. Homogeneity test is a test to know variant distribution same or not, and t-test is a test to know mean and variety from data [9]. However, if the data was not normally distributed then a nonparametric statistical analysis is performed, which does not have to assume that the data is normally distributed and homogeneous [9]. The nonparametric statistical analysis which used to compare the relationship between two free samples was the Mann-Whitney U test. Mann-Whitney U test is a test to know two free sample came from same population [8]. Fracture azimuth data obtained through field surveys showed tectonic effects in the study area, this would be compared with the linearity of the ridge and river linearity data showing the landscape and will be obtained whether the three are related, which means the landscape of the region is influenced by tectonics, or not.

3. Results and discussion
The results obtained through a field survey in the form of azimuth fracture data scattered in the Rawa Danau Area (figure 1). This data showed the influence of tectonics in the study area. The results obtained through analysis of satellite images using DEM SRTM data and ArcGIS 10.2.1.® by drawing a straight line that showed the direction of the ridge and river in the form of linearity of the ridge and linearity of the river, both data indicated the direction of the landscape formation in the research area (figure 2). The red line shows the linearity of the ridge and the yellow line shows the linearity of the river. Based on the second rosette diagram, the data showed the direction of NW-SE.

The three data obtained were then compared using statistical analysis. This analysis begins with the normality test to see data distribution. In this study the normality test using the Liliefors method and the alpha value of 0.05 was used, then the value is generated (Table 1). Based on this method, Lo is major difference between normal cumulative probability and empirical cumulative probability, and Ltable is value L from table. If the Lo value was smaller than the Ltable value (Lo < Ltable) then the data is normally distributed. However, based on the results obtained Lo value is greater than the Ltable value (Lo > Ltable) which means the data is not normally distributed. Then it cannot use parametric statistical analysis so that nonparametric statistical analysis is used without assuming the data is normally distributed and homogeneous.
Figure 1. Research area and distribution of fracture azimuth data points (green points).

Figure 2. (a) Ridge and river’s lineament map of the research area, (b) rosette diagram for the ridge, (c) rosette diagram for the river (dashed line), based on DEM SRTM satellite imagery.

Table 1. Lo and L_{table} values for normality test using the Liliefors method with an alpha value of 0.05.

| Value | Fracture azimuth | River linearity | Ridge linearity |
|-------|------------------|-----------------|-----------------|
| L_{o} | 0.878919         | 0.926488        | 0.821883        |
| L_{table} | 0.11075       | 0.111626        | 0.116337        |

The nonparametric statistical analysis used in this study was the Mann-Whitney U test to compare the relationship of two independent samples. This analysis is done using IBM SPSS Statistics® 25 so it can be obtained in table 2. If the value of Symp. Sig (2-tailed) is smaller than 0.05 (Symp. Sig < 0.05) then H_0 is accepted and H_1 is rejected, but if the value Symp. Sig (2-tailed) is greater than 0.05 (Symp. Sig > 0.05) then H_0 is rejected and H_1 is accepted.
Table 2. The results of the data comparison test using the Mann-Whitney U test.

| Value            | Test statistics | Fracture azimuth | River linearity | Fracture azimuth | Ridge linearity |
|------------------|-----------------|------------------|-----------------|------------------|-----------------|
| Mann-Whitney U   |                 | 1655.500         |                 | 1621.000         |                 |
| Wilcoxon W       |                 | 3800.500         |                 | 3332.000         |                 |
| Z                |                 | -1.868           |                 | -1.338           |                 |
| Symp. Sig (2-tailed) |             | 0.062            |                 | 0.181            |                 |

Based on the Mann-Whitney U test results above, the value Symp. Sig (2-tailed) is greater than 0.05 (Symp. Sig > 0.05), then Ho is rejected, which means the landscape of Rawa Danau area was not influenced by tectonic activity in its formation. The landscapes that are formed are due to volcanic activity and landslides due to weathering rocks, this is based on topography and the slope is steep and many landslides are found.

4. Conclusion

Based on this research, it can be concluded that the landscape formed in the Rawa Danau area is the result of volcanic activity and landslides due to weathering rocks. The fracture azimuth data obtained as a result of tectonic activity indicates that tectonic activity that occurred in the Rawa Danau area did not affect the shape of the landscape in the area. Morphotectonic research is useful to determine how influential tectonic activity occurs in the study area and is useful also to analyze the level of disaster that might occur in the area.

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