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Research Paper

Geological Structure of Jabungan Area, Semarang, Indonesia Using Vs and Vp/Vs Analysis of Microtremor Data Inversion

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ABSTRACT: *A geophysical survey was conducted in Jabungan Village, Banyumanik District, Semarang City with 52 data points collected. The geophysical method is a technique for identifying and analyzing subsurface geological structures. The HVSR method, which measures above the ground surface, was used to identify the subsurface geological structure. This study aims to determine the geological structure of the Jabungan Village area of Semarang using microtremor data and the HVSR method. The regional geology of the study area is composed of three rock formations: the Alluvium Formation, the Kaligetas Formation and the Kerek Formation. Data processing was done using Windaq, Geopsy, Dinver and Surfer. The Vs value obtained as a result of data processing ranged from 100 m/s to 1800 m/s. The obtained Vp/Vs ratio was between 1,5 to 3,1.*

KEYWORDS: *Rock Formation, HVSR Method, Microtremor.*

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I. INTRODUCTION

The Jabungan area is located in the Banyumanik District of Semarang City and features steep hills with an average slope of 30% and an altitude difference of up to 275 meters. This region's morphology has relatively steep conditions influenced by tectonic factors [2]. The Jabungan area has three rock formations, according to the geology map of Semarang [7] which are Kaligetas (Qpkg), Kerek (Tmk) and Alluvium (Qa). The research area also displays the structure of fault continuity. The Kaligetas Formation consists to tuffaceous sandstones, claystones and volcanic breccias. Breccia flows and lava with fine to coarse lava and tuff intercalation. At the bottom, tufan sandstone-containing claystone was discovered. The Kerek Formation is composed of alternating claystone, tuffaceous sandstone, conglomerate, volcanic breccia and limestone. Intercalated with claystone are siltstone and sandstone. The Alluvium Formation, which is river and lake sediment, is made up of pebble, gravel, sand, siltstone and limestone.

In this study, microtremor data was used using the Horizontal to Vertical Spectral Ratio (HVSR) method. The HVSR method is a cost-effective, environmentally friendly and effective method [6] that can be used in residential areas. The HVSR method is based on the assumption that the ratio of the horizontal to vertical spectral components of surface vibrations is a displacement function. This method yields the H/V curve, which at its peak reveals local information (site effect) in the form of the predominant frequency and the amplification factor of the waves recorded beneath the earth's surface [4]. The H/V curve is the result of HVSR processing, and its contains information in the form of the predominant frequency value (f_0) and the amplification factor value (A_0) [9]. According to what has been stated above, the purpose of acquiring microtremor data using the HVSR method in this study was to determine the boundaries of the rock formation in the Jabungan area.

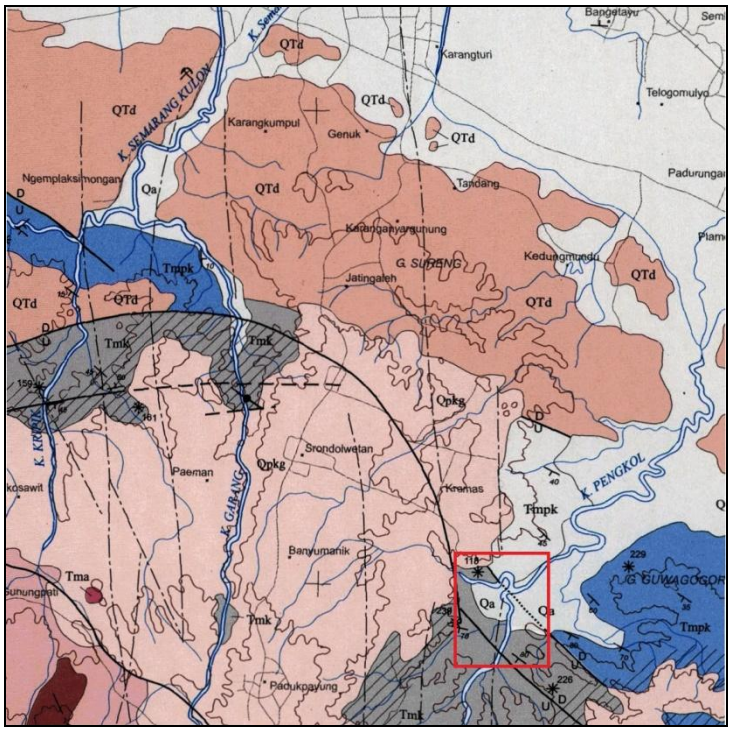


Figure 1. Research Area Map.

In the late 19th century, microtremor was not regarded as noise, but rather as a useful signal. Omori conducted microtremor research in 1908; in 1961, Tanai and Tanaka proposed microtremor application engineering. In 1970, Nagoshi and Igarashi introduced the technique of using the Horizontal to Vertical Spectral Ratio (HVSR) of microtremor. Nakamura invented and popularized the HVSR technique in 1989. Microtremor waves have a vibration amplitude of 0,1-1 microns and a velocity amplitude of 0,0001-0,1 cm/sec. Microtremor is defined as ground vibration with a microtremor amplitude that can be caused by both natural and human factors [5]. Nakamura proposed microtremor in 1989 by claiming that the ratio of the horizontal and vertical spectra of microtremor increases at the resonant frequency and peaks at that frequency. Microtremor method has a sensitivity to shear wave because this method cannot propagate through the fluid [8].

HVSR is a method that assumes the ratio of the horizontal to vertical spectrum of surface vibrations is a displacement function. The HVSR method generates a H/V curve with peaks indicating local information, such as the predominant frequency and amplification factor. In passive seismic, the HVSR method is used. This method has a wide range of applications, including local effect studies and micro zonation. The dominant frequency and amplification parameters generated by this method are related to the subsurface physical parameters in order to determine the characteristics of the study area.

II. METHODS

This study collected data from 52 points using microtremor data. Data collected through data acquisition in the field was processed using Geopsy software and the inversion process was carried out using Dinver software, which is included with Geopsy software. The data was then processed using Surfer software to produce 2D modeling. This study was carried out by surveying data acquisition design, microtremor data acquisition and data processing with Geopsy, Dinver and Surfer software.

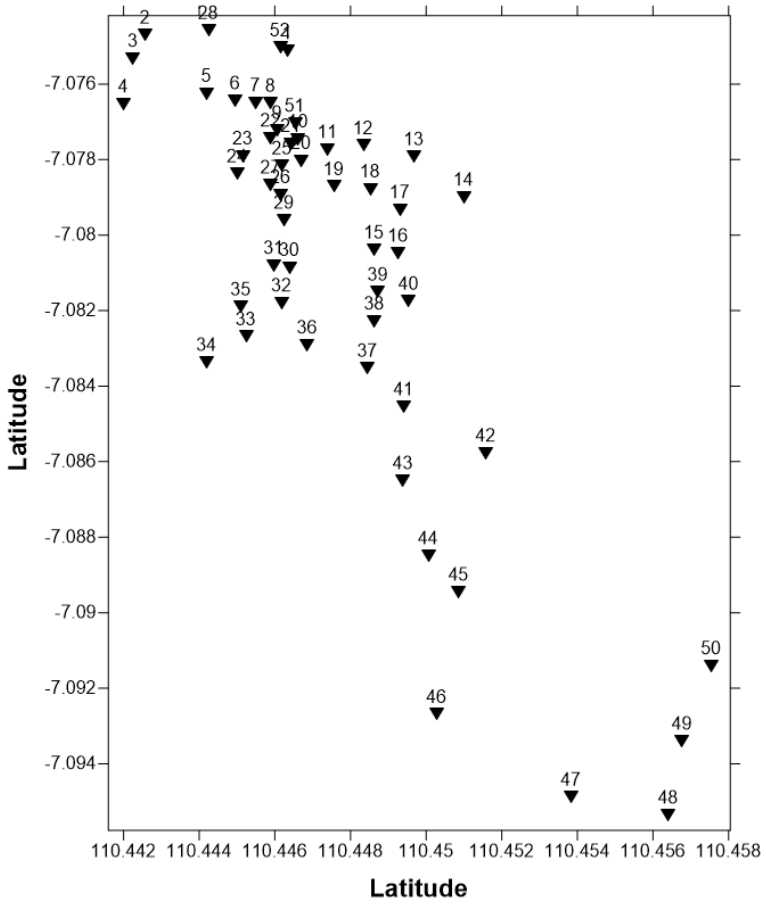


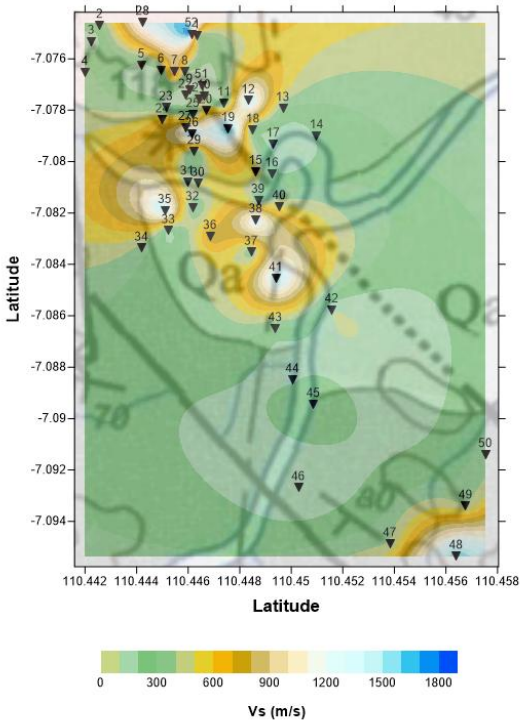
Figure 2. Map Of Acquisition All Points.

The collected data is then processed with software to obtain information on the structure of the subsurface layer in the study area. The data collected at the research site was opened in Windaq software to change the data format to *.txt* which was then saved in Notepad. After storing the data in *.txt* format, Geopsy software was used to obtain the H/V curve with the parameters obtained, namely the predominant frequency value (f_0) and amplification factor (A_0) at each acquisition point, which were saved in *.hv* format.

The Dinver software, which is included with the Geopsy software, was used for further data processing. Dinver software was used to invert data obtained by the ellipticity curve method. The parameters used in this ellipticity curve method were the P wave velocity (Vp), the S wave velocity (Vs), the sediment layer thickness and the density value. The final data processing was making 2D contours and profiling using the Surfer software to map conditions at the study site.

III. RESULT AND DISCUSSION

a)



b)

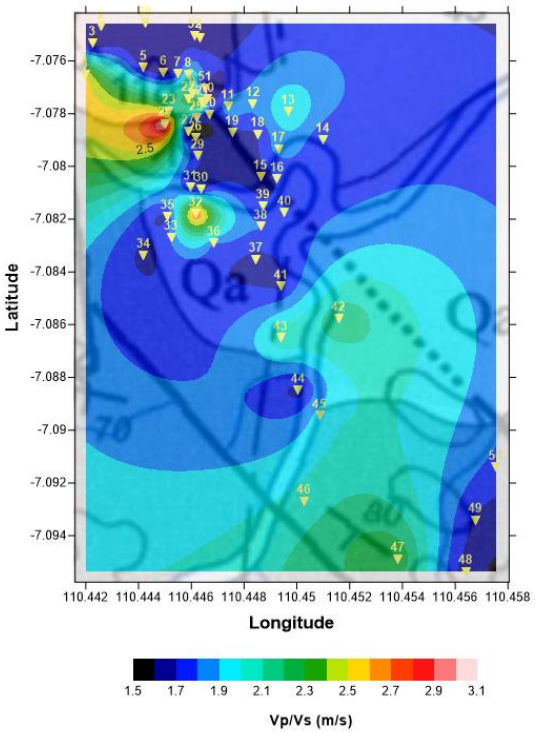


Figure 3. a) Vs Contour Map b) Vp/Vs Contour Map.

On the contour map depicted in Figure 3, the continuity of the fault is visible. A dense settlement exists in the northern part of the fault continuity. If unchecked, it will interfere with community activities. The density of a rock is directly proportional to the value of Vs. The higher the Vs value, the denser the rock density. This method can be used to assess the structural condition of the subsurface layer. Shear wave velocity, according to [3], can describe the lithological conditions of the subsurface layers. The higher the shear wave velocity value, the harder the soil layer properties, and vice versa, the lower the shear wave velocity value, the softer the soil layer properties. The classification of the Vs value: clay with Vs 100-350 m/s, gravel with Vs 100-430 m/s, limestone 600-3350 m/s and loose sand with Vs 150-500 m/s.

According to [1], the classification of the Vs value in figure 3 consists of hard rock with Vs>1500 m/s, rock with a Vs value of 750-1500m/s, hard soil and soft rock with a Vs value of 350-750 m/s, medium soil with a Vs value of 175-350 m/s and soft soil with a Vs <175 m/s. The Vs values obtained in this study ranged from 100 m/s to 1800 m/s. The value of shear wave velocity indicates that the soil layers in the study area are diverse. Water can enter the soil more easily in conditions where the soil has a high porosity.

One of the parameter values that can be used to determine the lithological condition of the subsurface layer is the Vp/Vs value. The Vp/Vs ratio is calculated by comparing the velocity of the P wave and the velocity of the S wave obtained from the inversion process. The values of Vp/Vs range between 1,5-3,1. The higher the Vp/Vs value, the softer the rock, and vice versa, the lower the Vp/Vs value, the harder the rock

IV. CONCLUSION

Based on the collection of microtremor data in the research area of Jabungan Village in Semarang to determine the subsurface geological structure, it can be concluded that the rock formations in the study area have three formations: Kaligetas formation, Kerek formation, and Alluvium formation. The Vs value obtained from data processing results ranges from 100 m/s to 1800 m/s. The Vp/Vs ratio has a value that ranges between 1,5 to 3,1. The lithology of the study area can be classified as clay, limestone, gravel, and loose sand layers.

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