

Poisson's ratio analysis (V_p/V_s) on volcanoes and geothermal potential areas in Central Java using tomography travel time method of grid search relocation hypocenter

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Abstract. Poisson's Ratio illustrates the elasticity properties of a rock. The value is affected by the ratio between the value of P and S wave velocity, where the high value ratio associated with partial melting while the low associated with gas saturated rock.

Java which has many volcanoes as a result of the collision between the Australian and Eurasian plates also effects of earthquakes that result the P and S wave. By tomography techniques the distribution of the value of Poisson's ratio can be known. Western Java was dominated by high Poisson's Ratio until Mount Slamet and Dieng in Central Java, while the eastern part of Java is dominated by low Poisson's Ratio. The difference of Poisson's Ratio is located in Central Java that is also supported by the difference characteristic of hot water manifestation in geothermal potential area in the west and east of Central Java Province. Poisson's ratio value is also lower with increasing depth proving that the cold oceanic plate entrance under the continental plate.

1. Introduction

Poisson's Ratio is a change in the geometry of an object depends on the amount of lateral strain and axial strain. The magnitude of Poisson's Ratio also depends on the P waves and S waves velocity [1]. The characteristic of P wave is the direction of propagation is in the same way with the direction of the movement and it is compressed, while the S wave has a characteristic propagation direction perpendicular to the direction of movement and it is the shear wave, so Poisson's Ratio is the ratio between the amount of strain due to compression force against the shear force.

Poisson's Ratio can calculated by Wadati diagram, where the arrival time of P wave as the Y axis and the difference between arrival time of S and P wave as the X axis. From the gradient of the linear regression is a V_p/V_s or Poisson's Ratio. Poisson's Ratio value indicates the elasticity properties of rocks at the points (force caused by the earthquake) in the rocks. In regions with geothermal manifestations, Poisson's Ratio value indicates a high degree of saturation of high water, because the presence of water will increase the value of Poisson's Ratio [2].

The existence of high temperature zones beneath the surface gives the variation of the P wave velocity (V_p), S wave velocity (V_s) and the Ratio of both of them (V_p / V_s), which also illustrates the value of Poisson's ratio. In the gas saturated rock, impairment of V_p is greater than V_s so that V_p / V_s or Poisson's Ratio has little value [3] whereas in rocks associated with partial melting, impairment V_s greater than V_p so that the value of V_p / V_s or Poisson's ratio is higher [4].

The purpose of this research is to describe the distribution of Poisson's Ratio value and its relationship with geothermal potential in Central Java as Mount Slamet as the center point using a tomography technique.



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A. Geothermal Potential In Central Java

The southern part of Central Java is one of the areas in Indonesia which has a geothermal potential. This is shown by the discovery of geothermal manifestations such as hot water in Cilacap, Kebumen and Wonosobo precisely on the area Panulisan, Cipari, Wadas Malang and Wadas Lintang (Figure 1). Java had a series of volcanic Oligocene-Middle Miocene and Pliocene-Quaternary. Volcanic formation series is related to the subduction of the Hindia-Australian Ocean Plate under Java at the end of Paleogene. Based on the geological map of Kebumen, Majenang, Pangandaran and Banyumas [5] rocks in the area consist of sedimentary rock, intrusion rock, rock as a result from the tectonic activities and sediment in the surface ranging from Pre Tertiary to Quaternary.

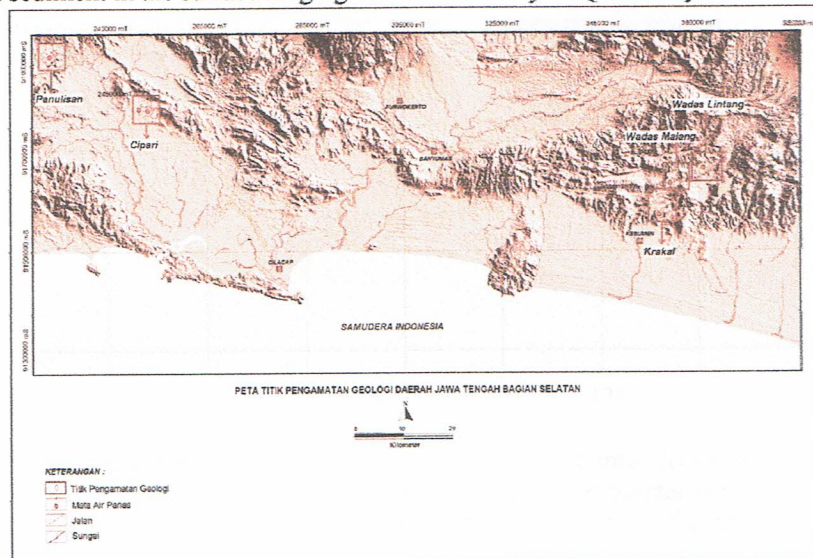


Figure 1. The distribution map of the geothermal manifestation and research area [5]

There are volcanism in the southern part of Central Java-as old Tertiary andesite formation [5]. In Cipari and Krakal, sediment deposition of sandstone and breccia unit are found that has characteristics of volcanic material. At the end of Miocene Pliocene, volcanic activity shifted to the north so that the arc magma is in the north of tertiary magmatism track Oligocene-Middle Miocene period.

Tectonic processes of Java on Plio-Pleistocene led to the appointment of rock deformation at the same area of research in the form of folding structures and faults. The pattern of the old structure back up and cause pattern old structure on younger lithology. Faults formed may contribute to the manifestation of hot water in the area.

In general manifestations of hot water found in Cipari, Panulisan, Wadas Lintang and Wadas Malang have temperature about 36°C-50.8°C. Hot Fluid coming from the hot water in the manifestation area of Cipari, Krakal and Panulisan that have high Cl ion concentration as the chloride water type, while the hot water in the area Wadas Lintang and Wadas Malang is a water type with a predominance of bicarbonate ions HCO_3 . Bicarbonate water type is suspected association with hot fluids rising gas containing CO_2 and condenses in the shallow aquifer.

It can be concluded that the establishment of a geothermal system in the Cipari, Krakal, Wadas Lintang and Wadas Malang associated with sedimentary basins. [6] believes that the formation of geothermal systems in sedimentary basins is the result of the circulation of the meteoric water along the fault or fracture zones in areas that have a high heat flow. Meanwhile, there is a breakthrough in

the Panulisan form igneous lava dome and Pliocene age. It gives hope about the geothermal manifestation. The existence of tectonic activity in Plio-Pliocene with the fault formation can act as a media release of hot fluid to the surface [5].

2. Methodology

The data used in this research is data earthquake data around Java that are downloaded from the USGS website since 1952 to 2002 with table AK-135 velocity models. The seismic data is relocated using Grid Search to get the value of the travel time calculation of the P and S wave. Then, using an early model of the table AK-135, the relocation of hypocenter inverted using tomographic techniques.

Before the tomographic inversion, performed model parameterize is needed by divided areas into blocks of a given size [7] as shown in Figure 2.

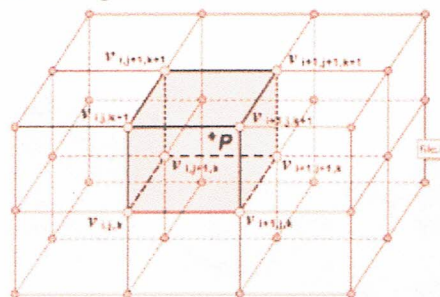


Figure 2. Model Parameterization [7]

In Figure 2 a model parameterization is done by dividing the area into blocks of the same size as the model initial of velocity (v), the point P in Figure 2 is assumed hypocenter point lies in the particular block. By using the Grid Search point P relocated to then be inverted and the resulting tomogram V_p / V_s .

Tomography technique that used can be calculate with equation (1)

$$T = \int_{source}^{receiver} \frac{1}{V} dl \quad (1)$$

with T is the arrival time of P and S waves at the seismic station, V is the velocity model and dl is the length of waves onto the blocks. Source and receiver in equation (1) is the hypocenter and the seismic station [7].

To get a model tomogram, the equation (1) is converted by first changing the equation (1) becomes:

$$T = \sum S_f dL_f \quad (2)$$

With S_f is the value of slowness ($1 / V$) for the block to f and dL_f is the length of the track on the block to f. Equation (2) is then inverted by first changing the equation (2) becomes:

$$d = Gm \quad (3)$$

With a data d is the arrival time of observation, G is a function forward modeling and m are the parameters of the model that will be sought in this case is V . Equation (3) then inverted is by using the following equation [8]:

$$m = (G^T G)^{-1} G^T d \quad (4)$$

3. Discussion

Sectional slices and tomographic inversion results V_p / V_s shown in Figure 3, 4 and 5 below:

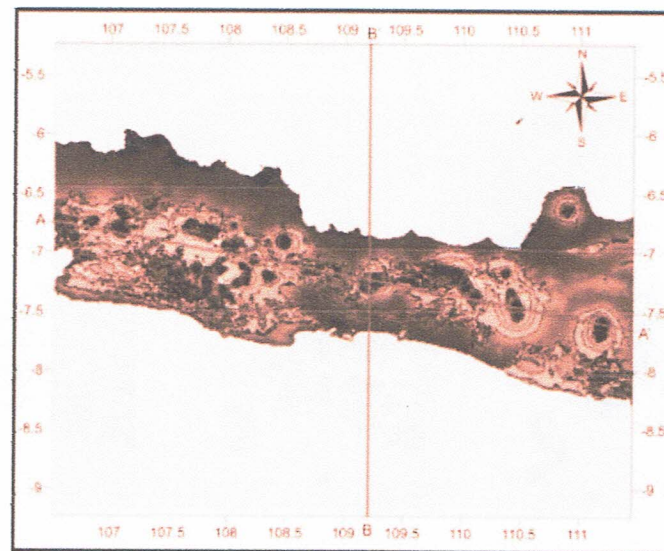


Figure 3. Sectional section of A-A' and B-B'

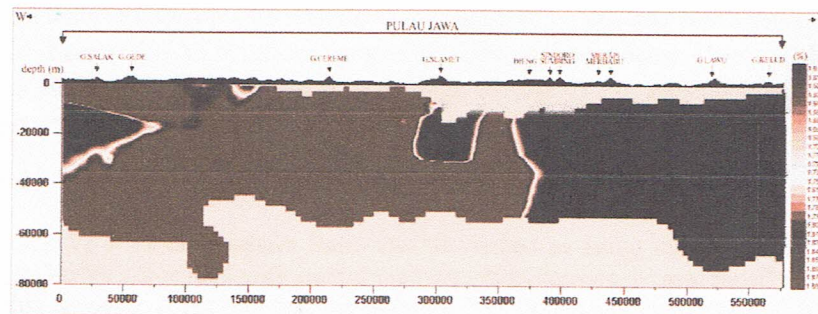


Figure 4. A-A' Tomogram

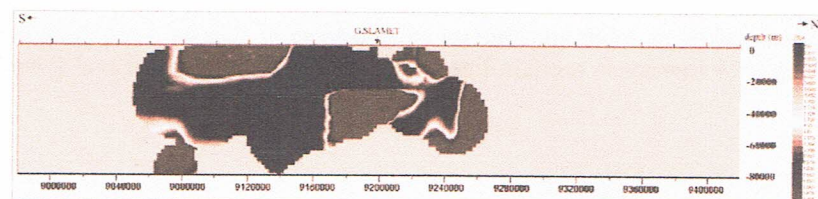


Figure 5. B-B' Tomogram

Figure 4 and 5 show that the high Poisson's Ratio is represented by red and the value of the low by blue color. From Figure 4 it is known that the value high Poisson's Ratio is in West Java until Mount Slamet which are some areas in Central Java, then from Dieng to the east is dominated by the low Poisson's Ratio. This means that in some areas of West Java and Central Java rocks is dominated by partial melting. Whereas in Figure 5 Poisson's ratio is lower dominates under of Mount Slamet associated with partial melting is low, that affect the pattern of the eruption of Mount Slamet is not periodic as Mount Merapi.

Tomogram under Central Java can be seen in Figure 6

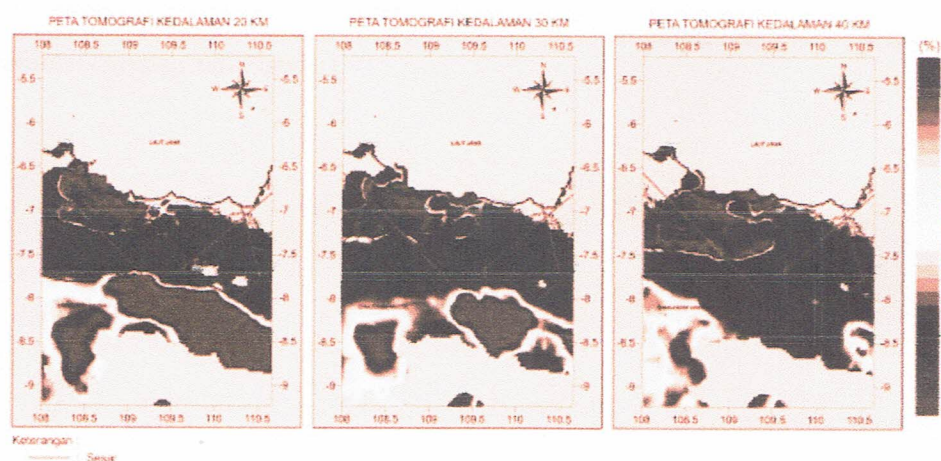


Figure 6. Tomogram under the Java

Figure 6 shows that the high V_p / V_s dominates at a depth of 20 km, and continued to decline up to a depth of 40 km. Lower V_p / V_s is increasing with the depth indicates oceanic plate cooler is cooler and entrance under the continental plate, because the high of V_p / V_s is associated with partial melting that has a high temperature.

4. Conclusion

Variations in the V_p / V_s or Poisson's Ratio can be viewed by using the technique of tomography, where the high V_p/V_s associated with partial melting while conversely associated with gas saturated rock [4]. In this research, it appears that the high V_p / V_s dominates in western of Java until Mount Slamet and Dieng, and to the east is dominated by low V_p / V_s . While the value of V_p / V_s also continued to decline for the increasing depth of proving that the oceanic plate is cooler and entrance under the continental plate. In addition, the value of V_p / V_s linked to areas that would potentially geothermal manifestations, as seen in cross-section tomography there are differences in the value of V_p / V_s in Central Java indicates there are different manifestations characteristic of geothermal areas.

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