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Determination of Volcanic Earthquake Hypocenter on Period 18 until 31 August 2017 Case Study of Mount Merapi, Yogyakarta, Indonesia

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Abstract. Indonesia became an area passed by the Pacific Ring of Fire which was the meeting place of two active tectonic plates, which caused Indonesia to have many volcanoes. One of them is Mount Merapi. Mount Merapi is located on the border between Central Java and the Special Region of Yogyakarta, which is located at 7°32.5'LS and 110°26.5'W with an altitude of 2,978 diameters of 28 km, an area of 300-400 km^2 and a volume of 150 km^3. Merapi is a stratovolcano-type volcano with a cone-shaped andesite-basaltic type of magma. Seismic method aims to find out more the characteristics of the volcano. One indicator to see the early possibility of eruption is the occurrence of volcanic type earthquake (VTA) which is then accompanied by the emergence of shallow volcanic type earthquake (VTB). Volcanic earthquake data of Mount Merapi which can be as many as 5 volcanic earthquake events in the period of August 18, 2017 to August 31, 2017. Hypocenter points obtained have varying depth at different times. The accuracy of hyposenter points can be influenced by the picking results of the arrival time of the primary wave. We can conclude that in the period August 18, 2017 to August 31, 2017 is a type of deep volcanic earthquake.

1. Introduction

Indonesia is a country that has the potential of natural resources and areas prone to natural disasters earthquakes and volcanic eruptions, because Indonesia is passed by three meetings tectonic plates; Indo-Australian Plate, Eurasian Plate and Pacific Plate [1]. In addition, Indonesia is also an area passed by the Pacific rings fire ring which is where the two tectonic plates are actively moving to move.

According to the Ministry of Energy and Mineral Resources, 80 of the total active volcanoes in Indonesia are volcanoes of type A and one of them is Mount Merapi. Mount Merapi is the youngest volcano in the southern part of Java Island. Mount Merapi according to Hamilton (1979) is an Indo-Australian plate subduction of 60o under the Eurasian plate at a speed of ~ 6.5 cm / year. The early symptoms of the eruption of Mount Merapi can be seen from various data showing the increased activity of Mount Merapi. One of the data used to see the increased activity of Mount Merapi is seismic data [5].

Seismic methods on volcanoes in volcano monitoring are closely related to volcanic seismic activity. The method aims to find out more about the characteristics of the volcano. One of the indicators to see the early possibility of eruption is the emergence of deep volcanic earthquakes (VTA) which are then accompanied by the emergence of shallow volcanic earthquakes (VTB) [5]. The data used are seismic data of volcanic earthquake recorded on digital seismogram at Central Research and Development Center of Geological Disaster Technology (BPPTKG). Based on the data above, seismic data processing is done to get hypocenter (earthquake source) from volcanic earthquake recorded seismogram.

2. Methodology

The data used is volcanic earthquake data of Mount Merapi in the form of "miniSEED file" in the period August 18, 2017 to August 31, 2017. During the period obtained 5 volcanic earthquake events.

2.1. Classification of Volcanic Earthquakes

a. In volcanic earthquake (type A / VA)

The source of this type of earthquake is located below the volcano at depths of 1 to 20 km. A type A quake can be caused by a magma that rises to the surface with fissures.

b. Shallow volcanic earthquakes (type B / VB)

The source of the type B volcanic earthquake is estimated to be less than 1 km from the active volcano crater [2].

2.2. Earthquake Parameters

a. Time of Earthquake *(Origin Time)*

The time of the earthquake is the first time energy release occurs on the Earth's tectonic plates that are subjected to collision or friction pressure and expressed in days, times, months, years, hours, minutes, seconds in UTC (*Universal Time Coordinated*) units. Generally, Origin time is determined from the intersection of the Tp line when Ts - Tp is equal to zero which can simply use the Wadati diagram shown in Figure 1.

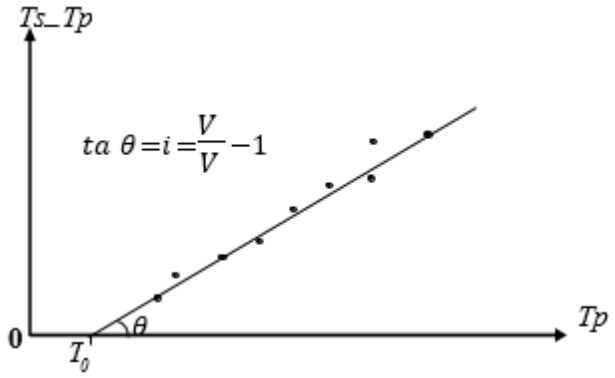


Figure 1. Diagram Wadati

In the Wadati diagram it does not take into account the model of the earth's inner structure, so it only assumes a homogeneous earth structure [3].

b. Hyposenter

Hypocenter is the epicenter of earthquake that is in the earth's surface.

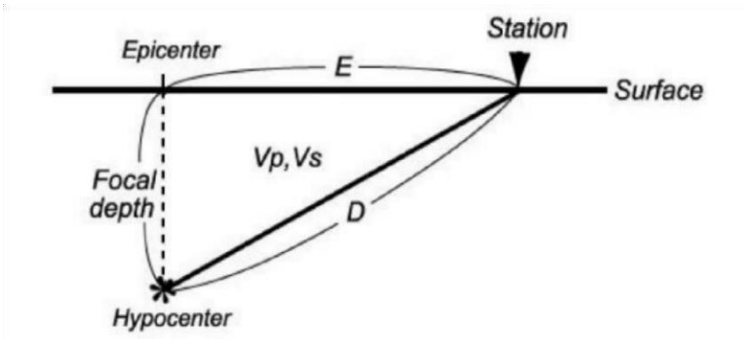


Figure 2. Jarak Hiposenter

From Figure 2, D is the distance of the hypocenter with the register station, and can be expressed by the following equation:

$D = Tpo * Vp$

$D = Tso * Vs = (Ts - To) * Vs$

$= \{(Ts - Tp) + (Tp - To)\} * Vs$ (3)

$= (Tsp + Tpo) * Vs$

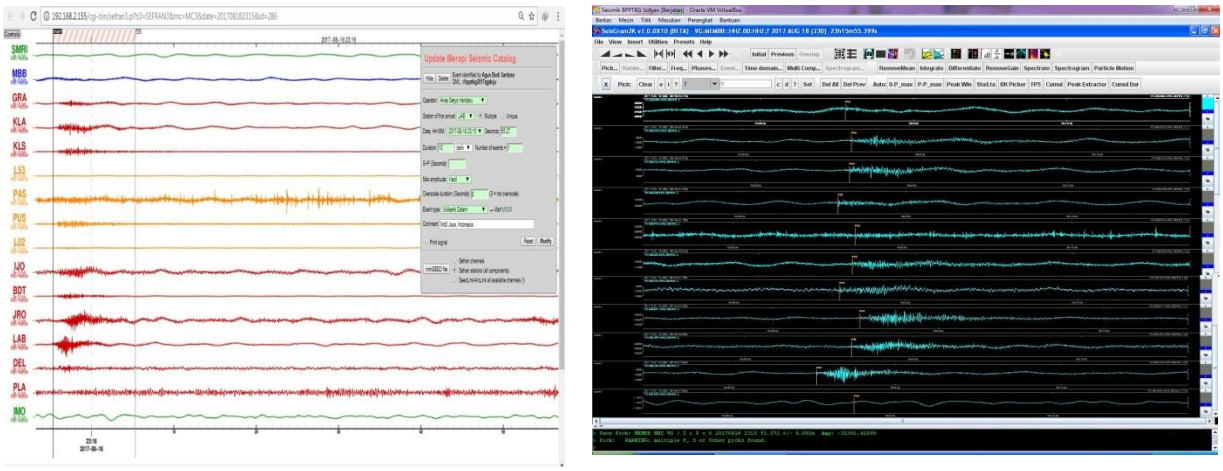
where Tsp is Ts - Tp. Ts is the arrival time of the S wave, Tp is the arrival time of the P wave, Vp represents the speed of wave P and Vs is the velocity of the S wave [3].

c. Epicenter

The epicenter is a point on the surface of the earth that is a perpendicular reflectivity of the hypocenter [5].

d. Magnitude

Magnitude is an earthquake parameter that measures the magnitude of the earthquake energy released from the source [5].



(a) (b)

Figure 3. (a) Seismic chart during volcanic earthquake 18 August 2017 at 23:16 WI (b) Picking on seismic data recorded by the earthquake on August 18, 2017 at 23:16.

3. Results and Discussion

Picking of earthquake data is performed on all volcanic earthquake data by taking the primary wave arrives time (tp) as shown in (Figure 4).

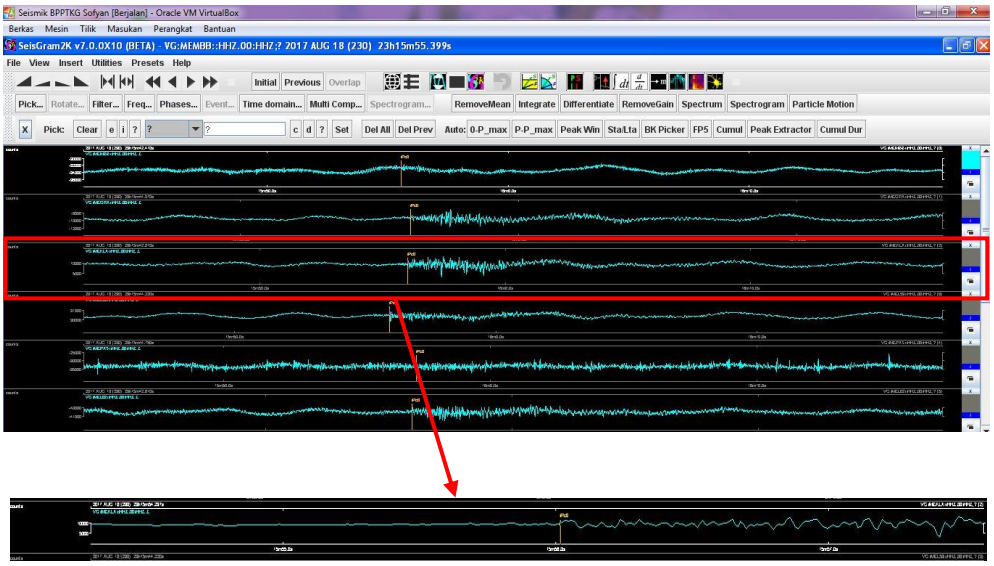


Figure 4. Picking the arrival time of the primary wave on the seismic data of the earthquake of 18 August at 23:16.

The result of picking the primary travel time (tp) affects the accuracy in determining the point of the hypocenter. The picking results obtained with the .py format run in Python program. So as to produce the coordinate point, depth (measured from the peak of Mount Merapi) as well as the imaginary image of the hypocenter as shown in (Figure 5).

The first quake obtained a hyposenter point with UTM X 438.402 and UTM Y 9166.667 and a depth of -4.8 kilometers. The second quake obtained a hypocenter point with UTM X 438.475 and UTM Y 9166.287 and a depth of -2.5 kilometers. The third quake obtained a hypocenter point with

UTM X 438.506 and UTM Y 9165.752 and a depth of -1.8 kilometers. The fourth quake obtained a hypocenter point with UTMX 438.665 and UTM Y 9166.549 and a depth of -3.6 kilometers. The fifth quake obtained a hyposenter point with UTM X 438.616 and UTM Y 9166.442 and a depth of -2.5 kilometers.

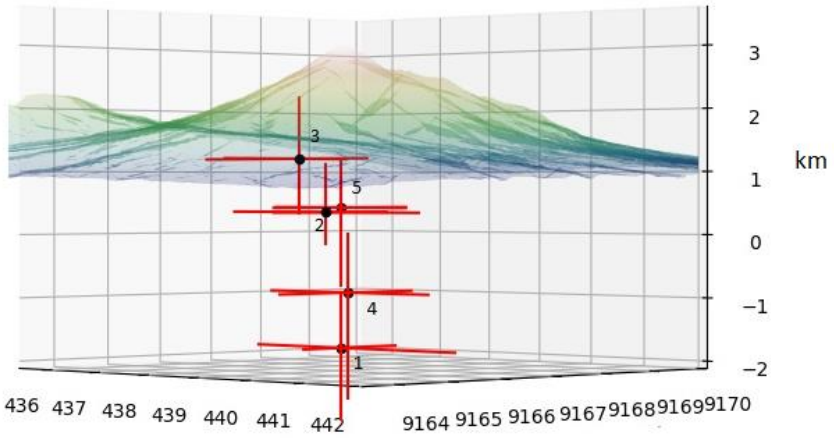


Figure 5. The hypocenter point of the volcanic earthquake in the period August 18, 2017 to August 31, 2017.

Table 1. Table of volcanic earthquake volcanic Mount Merapi period August 18, 2017 to August 31, 2017.

Date	Time	UTM X	UTM Y	Depth (km)
18 Agustus 2017	13.12.04,12	438,47	9166,662	-4,817
18 Agustus 2017	23.15.55,85	438,488	9166,323	-2,506
18 Agustus 2017	23.42.35,68	438,546	9165,717	-1,812
19 Agustus 2017	00.02.17,80	438,583	9166,581	-3,613
19 Agustus 2017	9.00.54,67	438,663	9166,479	-2,541

4. Conclusions

Based on this study, the hypocenter point obtained has varying depth at different times. The accuracy of hyposenter points can be influenced by the picking results of the arrival time of the primary wave. We can conclude that in the period August 18, 2017 to August 31, 2017 is a type of deep volcanic earthquake.

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