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Hypocenter Distribution of Sinabung Volcano during January - December 2015

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Abstract:- Sinabung volcano is one of the active volcanoes in Indonesia. the study used seismogram recording data from January - December 2015. from this period there were 163 volcanic earthquake events with 5 stations spread across the sinabung volcano area. this study is about the hypocenter distribution of the sinabung volcano earthquake. Hypocenter distribution is done using Geiger's method with Adaptive Damping (GAD). by analyzing the depth of the earthquake with a special technique (Geiger's method with Adaptive Damping), the hypocenter distribution is obtained at a depth of 1-5 kilometers.

Keywords:- *Hypocenter, GAD Method, Sinabung Vulcano, Seismic.*

I. INTRODUCTION

Sinabung volcano is located in Karo Regency, North Sumatra Province, Indonesia. The mountain is 2,460 m high and has coordinates 3.17°N 98.392°BT [1]. Sinabung volcano has been active since 1600 AD and experienced a phreatic eruption on August 27, 2010, so its status was changed from Category B to Category A to continue monitoring to minimize the dangers posed by the eruption [2]. In November 2013, phreatic to magmatic eruptions occurred and continued until mid-December 2013 [3].

Volcanoes that will erupt have seismic activities such as increased seismic activity, increased temperature and gas gusts, and surface deformation [4]. Sinabung volcano has a fairly high activity, this activity is always increasing because the energy released by the mountain can cause earthquakes [5]. The seismic investigation provides accurate information to understand dynamics of magma beneath the volcano [6.7.8.9]. VT earthquake classification can be used to determine the characteristics of earthquakes, including volcanic earthquakes, and map the Hypocenter [10].

According to the Minakami classification [11], type A volcanic-tectonic earthquakes (VT earthquakes) are visible in the P and S regions, usually dominating at frequencies of about 10 Hz or more and occurring at depths of 1-20 km. Meanwhile, VT B earthquakes often have indistinct P and S beginnings, with 1-5 Hz dominant frequencies. Although the onset time is unclear, there are some B-type earthquakes below, at a depth of about 3 km.

Geiger method [12] is applied to determine the location of the epicenter of an earthquake by calculating the difference in arrival times based on theoretical calculations and volcano observation calculations. In this method, the earth layer is assumed to consist of several horizontal layers and is a function of the distance between the epicenter and the lowest point of the earthquake [13]. The velocity parameter is known from the velocity model, while the time parameter is obtained from the results of P and S wave timing at at least three available stations. With this data, is used to determine the minimum remaining travel time to obtain seismic center data $(X_0, Y_0\ Z_0)$.

This study aims to determine the epicenter distribution of epicenters using GAD. Therefore, the study was conducted with new seismic data between January and December 2015 due to high seismic activity.

On 24 July 2015, thick white smoke and haze as high as 100 meters were seen, and lava flows were also seen from the top of Sinabung Vulcano as far as 500 - 1,000 m to the southeast. Furthermore, on July 25, 2015, it was recorded that around 1,111 people were still placed in 10 evacuation sites. Finally, on December 27, 2015, at least on Sinabung Vulcano there were 19 small outbursts and the status of Sinabung Vulcano is still at level IV (alert), and 9,319 people are still displaced in the shelter post provided [14]. Therefore, research was conducted on the epicenter distribution of the Sinabung volcano earthquake using the GAD method. Research was conducted on the distribution of the hypocenter of the Sinabung volcano earthquake using the GAD method.

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II. DATA WITH SEISMIC STASIUN

The data used in this research is data from Mount Sinabung seismogram recordings installed by the Center for Volcanology and Geological Disaster Mitigation (PVMBG) in the Mount Sinabung area, such as the SKN Station (Sukanalu), the KWR Station (Lau Kawar), SBY Station (Sibayak), MDD Station (Mardingding) and KBY Station (Kebayaken). The location of the stations around Mount Sinabung can be seen in Figure 1. The station closest to the peak of Mount Sinabyng is KWR with a distance of 0.92 km and the distance furthest from the peak location is SBY with a distance of 12.22 Km. The peak point on Mount Sinabung is 98.39278 and 3.17 Km.

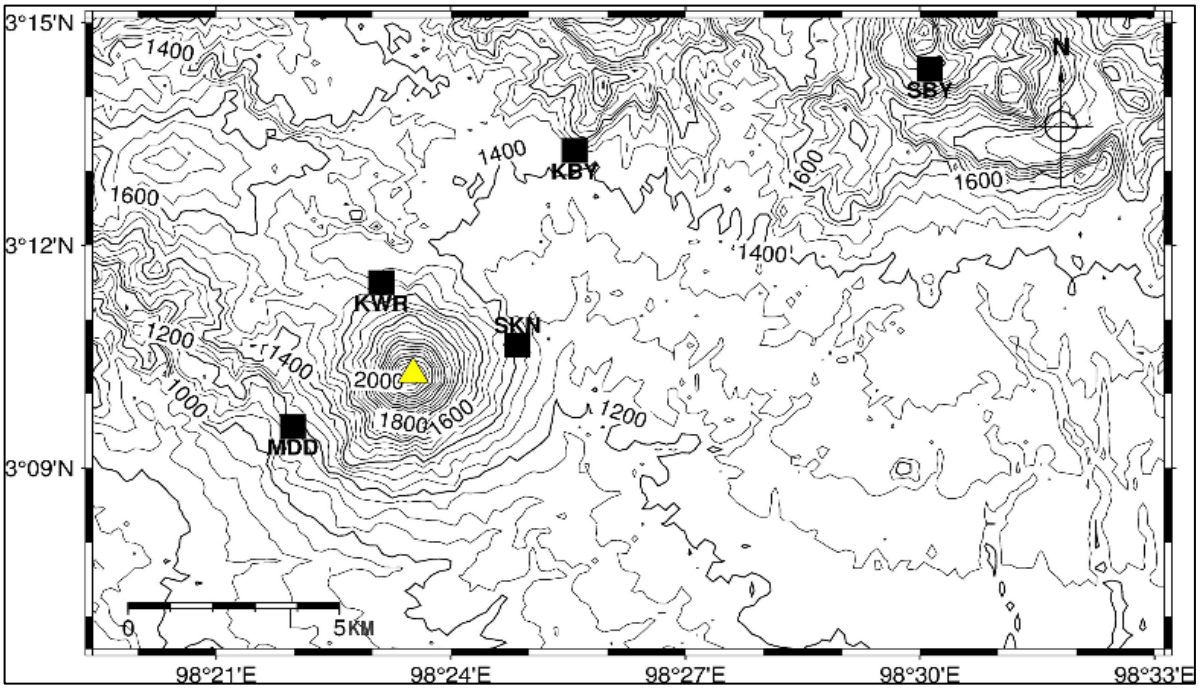

Fig 1. Map of Seismic Station at Sinabung that used in this Study. Black Rectangle and Yellow Triangle Correspond to the Seismic Station and Active Crater, Respectively.

The data used in this study is seismic recording data from PVMBG Sinabung Volcano from January to December 2015; 163 data were obtained from PVMBG. Figure 2 is an example of VT waves recorded on April 15, 2015.

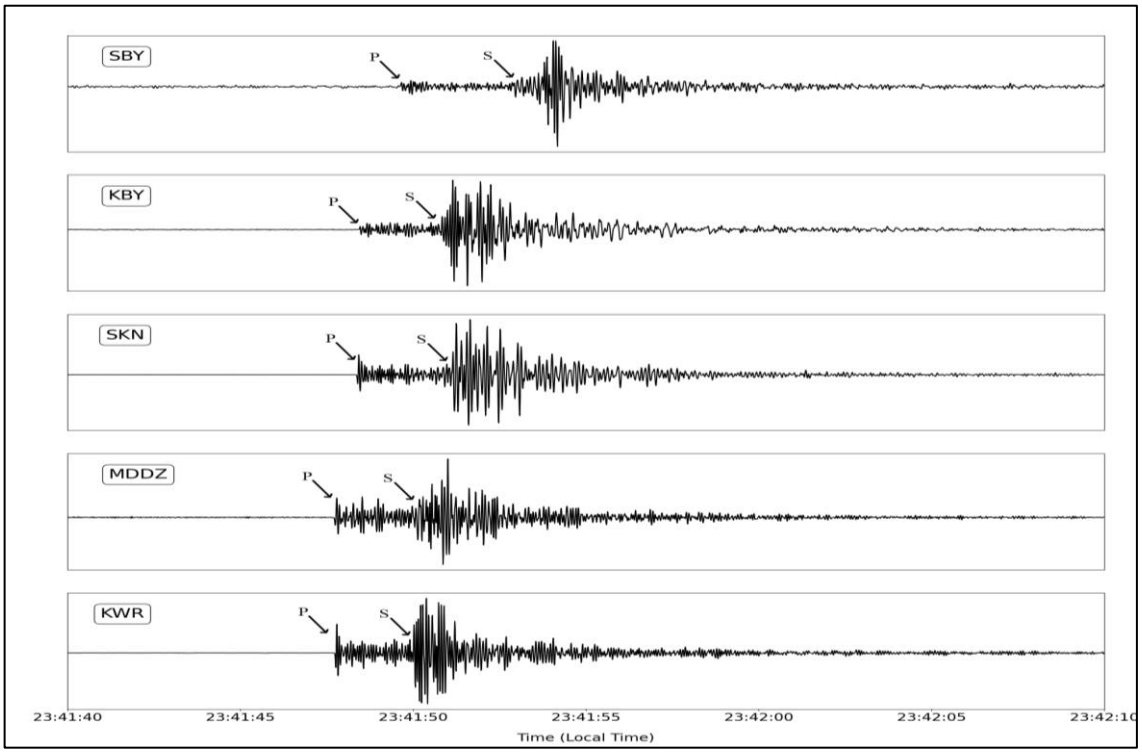

Fig 2. Example of the VT Earthquake Waveform Recorded on April 15, 2015 at 23:41:40 – 23:42:30

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III. METODOLOGY

This research uses secondary data, namely seismic data obtained from seismic recordings at each station around Sinabung Volcano. The recorded data is then analyzed using the LS7_WVE application to read seismic waves from each observation station. This software can read the data every hour and display the arrival time of P and S waves. These waves are amplified until an earthquake is detected. Before determining the epicenter of a volcano, the primary parameter that is first determined is the time of the quake or the time of occurrence. Determination of the time of earthquake occurrence using the Wadati map This Wadati map is used to check the linear relationship and quality of P and S time [15].

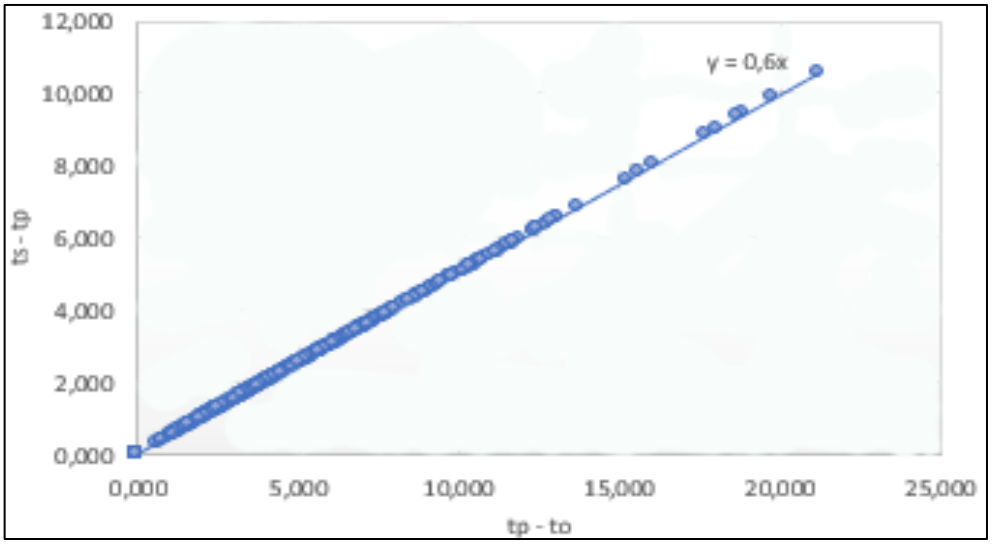

Fig 3. Wadati Diagram of VT Events During January-December 2015

The Wadati diagram is a parameter with good sampling quality by plotting the difference of S-wave and P-wave arrival times (Ts-Tp) on the Y axis and the P-wave arrival time on the X axis [16]. The difference in the arrival times of P and S waves will continue to increase proportionally with the increase in the observed P wave arrival time [17], which is consistent with the fact that the farther away the station is, the longer the P wave arrival time is. It runs. It is essential to record the waves transmitted to the receiving station. The Wadati diagram with a slope (Vp/Vs-1) between 0.6 to 0.9 is classified as a good selection [18]; from the classification, the value of the Wadati diagram is y = 0.6 x, as shown in Figure 3.

In this study, the seismic event used is the VT earthquake, and the data obtained is stored in a notebook in .dat format as input data for the GAD program. Next, convert each station's longitude and latitude coordinates to UTM format. The data used to determine the epicenter and epicenter is the station's location, and the velocity and arrival time of the P and S waves are calculated in advance using GAD software (Geiger method with Adaptive Damping) [12]. After the data were imported into Origin software, the epicenter was generated from the inverted x and z values, while the hypocenter was obtained from the x and y values.

IV. DISCUSSION

Data processing to determine the epicenter of Sinabung Volcano was carried out using seismic recordings from five stations scattered around the Sinabung Volcano area from January to December 2015. The earthquake was analyzed as a VT earthquake because VT earthquakes occur due to magmatic activity from below, above the surface before the eruption occurs [19]. The determination of the epicenter and epicenter of Sinabung Volcano with the GAD method includes determining tp and ts at each event. The epicenter in Figure 4 is the location of volcanic earthquake vibrations represented below the point (0,0) with a scale of distribution of the location of volcanic earthquake vibrations in kilometers (km). It can be seen that the epicenter is at a depth of 1 to 5 km below the summit of Sinabung Volcano. The epicenter is around the summit of Sinabung Volcano, which primarily extends north.

Research conducted by Indrastuti et al. [20] on the topography of Sinabung Volcano in the inter-eruption period October - July 2013 found that the hypocenter location is about 8 km below the peak of Sinabung Volcano. In addition, Ipmawan et al. [21] have conducted research on magma intrusion in the pre-magmatic period (2010 - 2013) Sinabung Volcano VT earthquake hypocenter at a depth of 1-10 km.

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Then Kurnia et al [22] conducted research in the period 2012 - May 2013 from the results of the comparison of the maximum value of horizontal and vertical deformation of Continuous Real-Time GPS observations found the depth of the earthquake source ranging from 2 - 9 km from the top of the crater, at the time of the eruption in 2010 then Sinabung Volcano spewed about more than 1,000,000 m3 in other words the volume of material in the body of Sinabung Volcano not all spewed during the eruption.

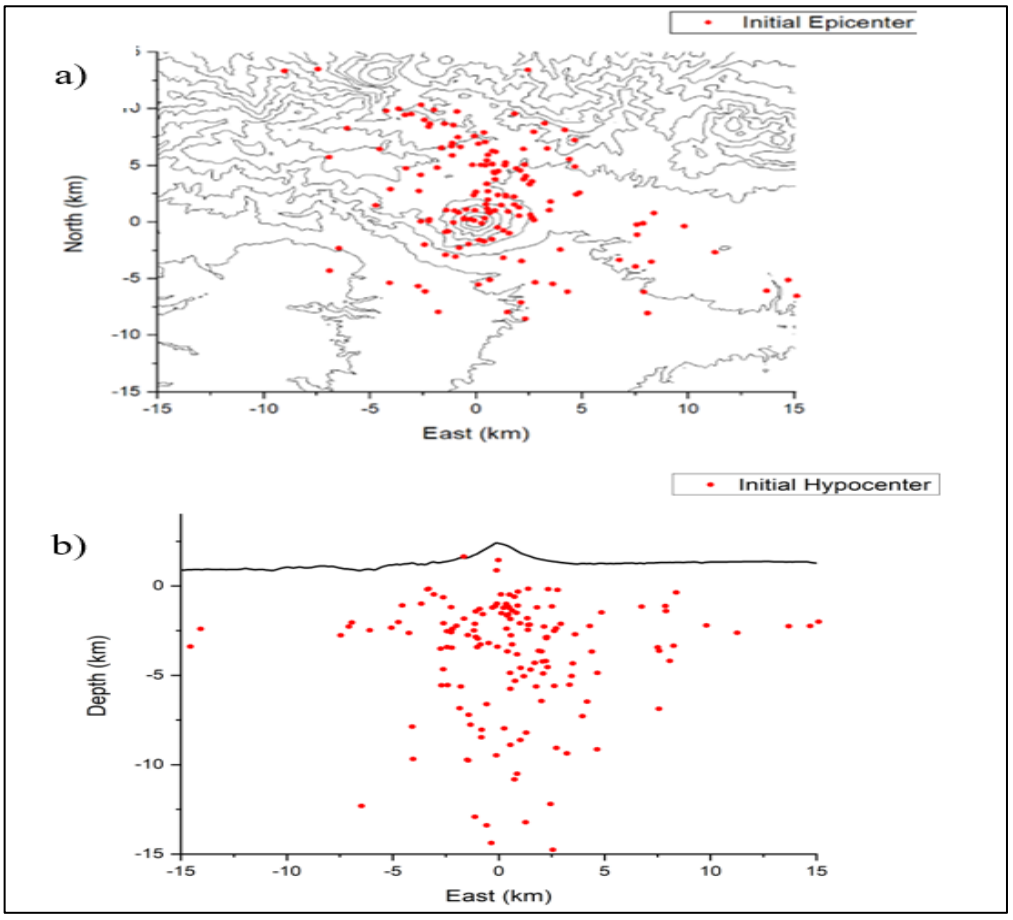

Fig 4 a) These are the Underground Locations where Earthquakes Originate beneath Sinabung Volcano during the Period of January to December 2015, b) These are the Points on the Earth's Surface Directly above the Earthquake sources (Hypocenters) Sinabung Volcano during the Period of January to December 2015.

V. CONCLUSION

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The VT earthquakes on Sinabung Volcano from January to December 2015 were analyzed to obtain the hypocenter and epicenter using five stations spread across the Sinabung Volcano area. The data amounted to 163 and was processed using the Geiger method, obtaining a hypocenter depth of 1 - 5 km. The earthquake epicenter spread around the peak of Sinabung Volcano, where the distance epicenter spread with the dominant to the north.

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