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# PROCEEDING INDONESIAN CONFERENCE OF GEOTHERMAL, MINERALOGY AND VOLCANOLOGY (ICGMV) 2015

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# Subsurface Tomography Studies Around Mount Slamet Area Based on Earthquake Data Which Relocate Using Guided Grid Search Method And The Impact In Mitigation Process of Erupsion Disaster

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## ABSTRACT

**Slamet is a vulcano that located in Central Java Province-Indonesia, exactly on 7°14'30"N and 109°12'30"E, with 3432 meters of height. It is type A volcano. The eruption is recorded since 1772. Earthquake around Slamet constists of tectonic and vulcanic earthquake. The deepest of hypocenter is located in 300 km under the top of the volcano. The hypocenter is relocated using guided grid search method and with tomographic tehniques subsurface imaging is done. Based on tomogram result, the boundaries between high and low velocity zones is more visible in the tomogram hypocenter after relocation than before. There are dominant low velocity anomaly in under and east of Slamet. It is expected as hot fluid. so peoples that live in east of Slamet should be a priority in the mitigation process of erupsion disaster.**

## INTRODUCTION

Slamet mountain with an elevation of 3432 meters is one of type A volcano because the eruption that occured since 1600. This mountain is located in Central Java, Indonesia, exactly on 7°14'30" S and 109°12'30" E. Administratively, it is located into five disctrict, there are Brebes, Tegal, Pemalang, Banyumas and Purbalingga (Maryanto et al, 2012). On April 30th in 2014, there was increased status of level II to level III. The status is given by Pusat Vulkanologi dan Mitigasi Bencana Geologi (PVMBG) as an early warning to communities that living around the vulcano (BNPB, 2014).

Mount Slamet is composed by old Slamet mount, young Slamet mount in the east and intermediate Slamet. Group of volcanic deposits eruption product consist of melt andesite lava and and pyroclastic deposits that have changed by hydrothermal alteration and group of young Slamet mount consist of melt basaltic lava and pyroclastic (Haar 1935; Harloff 1933; Djuri 1975 and Sutawidjaja dkk 1985; Pardyanto 1971:1990 op cit Maryanto dkk, 2012).

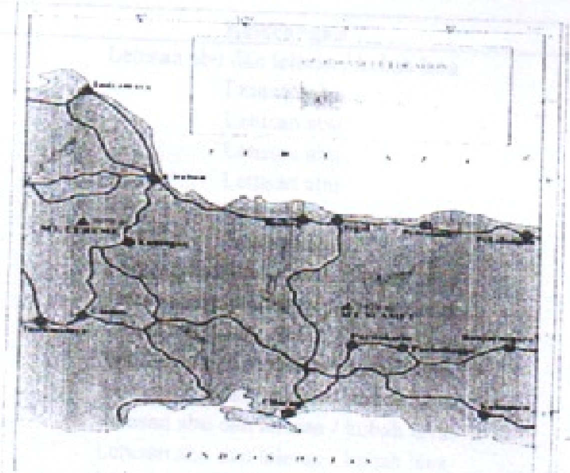


**Figure 1.** Slamet Mount Location

Volcanic rocks of old Slamet mount and young Slamet mount in the north and intermediate Slamet mount in the south is bounded by fault system that opens to the east caused by the structure with the trending from southwest to northeast. There are 35 cinder cones with a base diameter range between 130-750 meters with a height of 250 meters. Theese are include of volcanoes monogenesis group that formed at 0.042 ± 0.020 Ma (Sutawidjaja & Sukhyar, 2009 op cit Maryanto, 2012).

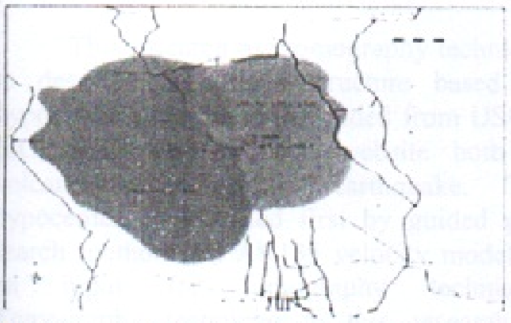


**Figure 2.** Map of old Slamet mount and young Slamet mount (Sutawidjaja and Sukhyar, 2009)

Based on Slamet mount activities record since at least two centuries ago, there were more than 30 times of the eruption, in the form both of ash eruption and lava melting. Slamet mount recorded erupted since 1772 with a weak explosive eruption character (volcano and efusive type) (Pratomo 2006; 2010 op cit Maryanto dkk, 2012). Slamet mount activities record since two centuries ago can be seen in Table 1.

According to Maryanto et al (2012), volcanic activity of the eruption in 2009 was dominated by shallow and deep volcano-tectonic earthquake. By tomographic technique, subsurface structure can be described based on hypocenter data. Then, the tomogram can be interpreted in geology which is expected to assits in the mitigation of volcanic eruption disaster

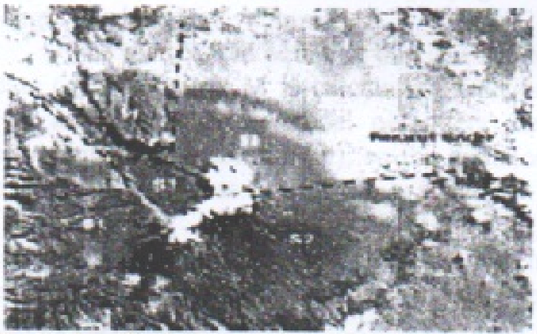


**Figure 3.** Evolution of Slamet mount based on Landsat image analysis (Bronto and Pratomo, 2010 op cit Maryanto dkk, 2012).

**Table 1.** Slamet mount activities record since two centuries ago (Kusumadinata 1979; Abdurachman dkk, 2007 op cit Maryanto dkk, 2012)

| Tahun | Tanggal - Bulan | Keterangan |
|---|---|---|
| 1772 | 11-12 Agustus | Letusan abu dan leleran / kubah lava |
| 1825 | Oktober | Letusan abu |
| 1935 | September | Letusan abu |
| 1849 | 1 Desember | Letusan abu |
| 1860 | 19 Maret dan 11 April | Letusan abu |
| 1875 | Mei, Juni, Nov, Desember | Letusan abu |
| 1885 | 21-30 Maret | Letusan abu |
| 1904 | 14 Juli - 9 Agustus | Letusan abu dan leleran / kubah lava |
| 1923 | Juni | Letusan abu dan leleran / kubah lava |
| 1926 | November | Letusan abu dan leleran / kubah lava |
| 1927 | 27 Februari | Letusan abu dan leleran / kubah lava |
| 1928 | 20-29 Maret dan 8-12 Mei | Letusan abu dan leleran / kubah lava |
| 1929 | 6,7 dan 15 Juni | Letusan abu dan leleran / kubah lava |
| 1930 | 2-13 April | Letusan abu dan leleran / kubah lava |
| 1932 | 1 Juli dan 20 September | Letusan abu dan leleran / kubah lava |
| 1939 | 18 Maret, April, 6 Mei, 15 Juli, 4 Desember | Letusan abu |
| 1940 | 15-20 Maret dan 15 April | Letusan abu |
| 1953 | Juli, Agustus, Oktober | Letusan abu dan leleran / kubah lava |
| 1955 | 12-13 November, 6-16 Desember | Letusan abu dan leleran / kubah lava |
| 1957 | 8 Februari | Letusan abu |
| 1958 | 17 April, 4-6 Mei, 13 Oktober, Desember | Letusan abu dan leleran / kubah lava |
| 1960 | Desember | Letusan abu |
| 1961 | Januari | Letusan abu |
| 1966 | ? | Letusan abu |
| 1969 | Juni, Juli, Agustus | Letusan abu |
| 1973 | Agustus | Letusan abu dan leleran / kubah lava |

| | | |
|---|---|---|
| 1988 | 12-13 Juli | Letusan abu dan leleran / kubah lava |
| 2009 | 23 April - 6 Mei | Letusan abu dan lontaran lava pijar (tipe Stromboli) |

## METHODS

This research use tomography technique to describe subsurface structure based on hypocenter data that downloaded from USGS, ISC, EHB and NCDEC website both of volcano and tectonic earthquake. The hypocenter is relocated first by guided grid search method and AK135 velocity model as an input for tomography technique. Tomography technique in this research is travel time tomography by using P wave of earthquake. Guided grid search method is used to relocate the hypocenter because it is a global search technique that can describe objective surface function more through by improving its efficiency with give higher probability value on the model that close to the solution than the model that far from the solution (Grandis, 2009).

Travel time tomography technique involves two modelling, there are forward and inverse modelling. Forward modelling is done by determining the parameters first, then examined whether the model generates data that according to observed data. While inverse modelling is opposite with forward modelling, it is try to describe the model based on the parameters (Hidayantunnisak). Parameters model is done by determining the cell size of the research area first, then seismic wave propatagion length is calculated for each cell with the hypocenter as the source and seismic monitoring stasions as the receiver, as illustrated in Figure 4

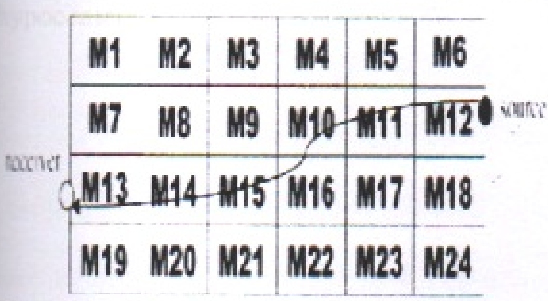



**Figure 4.** Illustration of seismic wave propagation in each cell (Hidayatunnisak, ___ )

Seismic wave propagation length can be calculated by equation (1)

$$P_i = \sum_{j=1}^{N} M_j S_j \qquad (1)$$

with $P_i$ is seismic wave travel time matrix, $M_j$ is seismic wave propagation length in each cell matrix , and $S_j$ is slowness in each cell matrix. The cell that not passed by seismic wave will has zero seismic wave propagation length's value (Hidayatunnisak, ___ ).

The matrix P in equation one is a vector data (d), the matrix M is calculation function (G) and matrix S is model paramters that searching for the solution(m), so the equation one can be written as:

$$d = Gm \qquad (2)$$

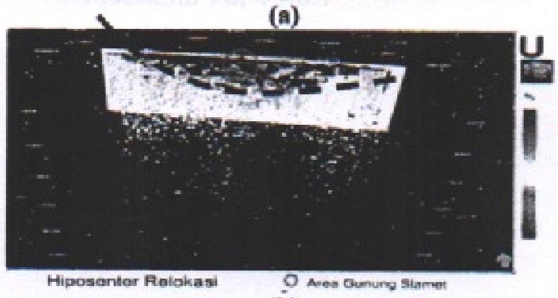
By using least square inversion method in equation (3), the solution of paramters model can be calculated

$$m = \left[G^T G\right]^{-1} G^T d \qquad (3)$$

## DISCUSSION

Based on relocating hypocenter data and AK135 velocity model as input of tomography technique, tomogram of subsurface in velocity model under Slamet mount is obtainable like in Figure 5


(a)




(b)

**Figure 5.** Velocity model around Slamet mount by travel time tompgraphy technique based on hypocenter data (a) before relocated; (b) after relocated

It can be seen from Figure 5, that hypocenter after relocated is more convergence and shallower than before. Beside that, the bound of low velocity and high velocity zones is more clearly (in Figure 5 it is showed by dashed black line). High hypocenter distribution is showing high geological activity. It is usually associated with hot fluid.

P wave is used in this research because it can pass the fluid medium. Fluid absrop the wave's energy so the velocity is weakened. The high temperature which is makes the particle movement more free also affect the P wave's velocity weakens. In Figure 5, low and high velocity be marked with red and blue colour.

Based on Figure 5 (b), it can be seen that low velocity zone in the east of Slamet mount is larger than in the west because there are the series of active volcanoes along Central Java to East Java. Under the Slamet mount, there are low velocity zone bounded by high velocity bound in the east, west and below the Slamet exactly. High velocity zone in the west is larger than in the east. From the hypocenter distribution, the dominant earthquake around Slamet mount is deep tectonic earthquake and bounded by high velocity zone. It is predicted as a cause the eruption in Slamet mount not as routine as Merapi mount. But if we see from the low velocity zone distribution, the area in the east of Slamet mount is more troubled because of the eruption.

## CONCLUSION

Travel time tomography with P wave can describe the subsurface by using hypocenter data. But the hypocenter data must be relocated first. Relocating hypocenter can improve the velocity model of the subsurface like in this research by relocating the hypocenter bound of low and high velocity zones is more clearly.

From the tomogram of subsurface around Slamet mount, there are low velocity zone under the Slamet mount that bounded by high velocity zone in the west and east, but the high velocity zone in the west is larger than the east, so the communities that living in the east of Slamet mount is more troubled because of the eruption. From the tomogram too, there is high velocity zone below the Slamet mount exactly, it is predicted as a cause that the eruption in Slamet mount not as routine as Merapi mount.

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