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Preliminary Results of Dense Seismic Network Monitoring Study in Merapi Active Volcano: International Research Collaboration of DOMERAPI Project

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DOMERAPI Project is international research collaboration between Indonesian and French teams. This project focuses on Merapi, one of the most active volcanoes in Indonesia, through a study on volcano monitoring, experimental petrology, physical volcanology, geophysical structure imaging, and numerical modeling of magmatic processes. For the seismic monitoring in Merapi volcano, we have been deploying 46 seismometer stations since September 2013, which has led to one of the densest seismic networks in the world for volcano active monitoring. We have attempted to understand deep magmatic processes beneath Merapi volcano by analyzing subsurface seismic velocities. We have been conducting seismicity analysis including event identification and volcano-tectonic hypocenter determination as well as determining an initial 1-D seismic velocities model. Finally, we will conduct seismic velocities subsurface imaging by applying travel time seismic tomographic inversion, ambient noise tomography and attenuation seismic tomography. We will deliver our preliminary results during the meeting in more details.

1. INTRODUCTION

Indonesia is surrounded by a chain of active volcanoes. The situation can be an advantage such as for geothermal purposes but on the other side, can lead to natural disasters caused by volcanic activity. The understanding of volcanic dynamic is crucial to anticipate and prepare solutions for any possibility of hazards. Mt. Merapi has been showing the evidence of eruption since 7000 years ago (Wagner, 2007). It poses great hazard for the population, caused by its eruptions and seismic activities. However, eruptions are almost always preceded and followed by volcanic unrest, indicated by strong variation in the dynamic process caused by internal forces. Such indicators are usually called seismo-volcanic signals. Seismo-volcanic signals are the blueprint of the actual conditions inside the volcano and therefore they can be used to obtain the physical properties of the volcano.

Since the eruption of 2010, Merapi has shown unusual activity compared to that of recent decades. Since 2012, powerful phreatic explosions have been observed, some of which are preceded by LF signals. We also observed LF signals not associated with explosive activity. The LF signals are typically associated with activity in the conduit (Inza, 2011). Knowledge of the position of the source of earthquakes associated with superficial magma movements is fundamental to understanding the physical processes occurring in the conduit.

2. STUDY AREA AND DATA

The subject of the study is Mt. Merapi, which is located in Central Java, Indonesia. Mt. Merapi is a stratovolcano that is one of the most active volcanoes in the world. A total of 46 triaxial broad-band seismic arrays were deployed around the volcano and also on the southern part of the volcano (Mt. Kidul and its surrounding areas) to estimate the back azimuth and also the source depth of the elastic signal (Figure 1). The measurements are carried out for approximately a year, and data downloaded every month from all stations for further processing (Figure 2).

This project is conducted as research cooperation between university institutions (Bandung Institute of Technology and University of Gajah Mada), The Centre for Volcanology and Geological Hazard Mitigation (CVGHM), and Institut de Recherche pour le Développement (IRD) of France. MOU of this cooperation was signed in 2012 and 2013.

3. CURRENT AND FUTURE WORK

We have identified earthquake events manually and carefully, and then picked arrival times of P and S waves from October 2013 to February 2014. The average number of identified local seismic events for each month is around 20. In the near future, we will locate and relocate hypocenters of seismic events. Furthermore, we will run seismic tomography from a local earthquake around Java region, recorded by DOMERAPI network, to analyze the seismic structure, for there exists a former hypothesis about the second magma chamber below Merapi summit (Ratdomopurbo dan Poupinet, 2000; Hidayati et al., 2008). Based on previous studies, there were hypotheses explaining two possibilities of magma chamber locations. First, the main magma chamber exists more than 5.0 km below the summit. This was modelled by Beauducel et al., (2000) using displacement data. Second, a hypothetic temporary magma chamber exists less than 1.5 km below the summit. This project is partly being run to test these hypotheses. The deep magma structure can be delineated by using ray paths from earthquakes occurring outside Merapi volcano, recorded by seismometers around the volcano. Figure 3 shows an example of a local earthquake recorded by DOMERAPI network with the shortest difference time between P wave and S wave of about 2 second.

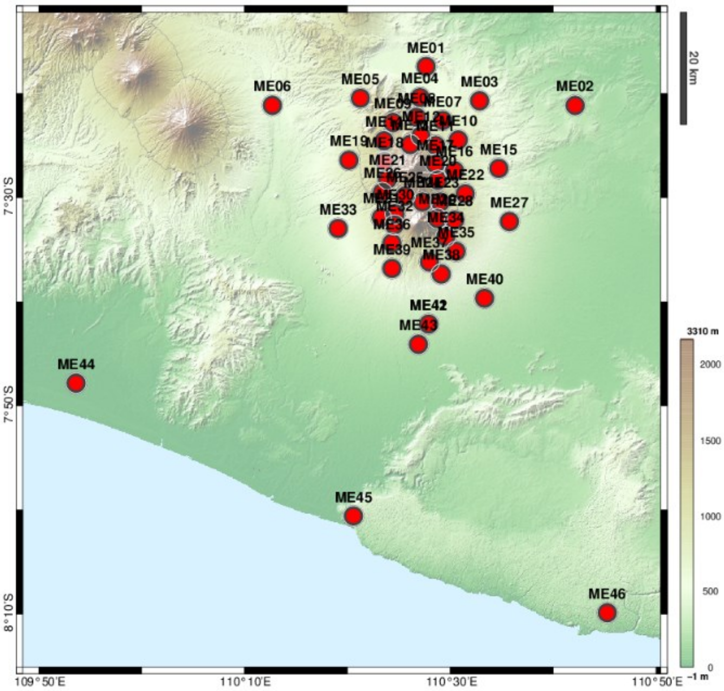

Figure 1: A figure showing DOMERAPI seismometer network (filled red circles) around Mt. Merapi in Cenctral Java, Indonesia.

Figure 2: A figure showing Seismometer installation processes.

DOMERAPI seismic network uses broadband seismometers, so local events are not the only ones recorded but also regional events such as is showed on Figure 4 (The earthquake occurred in Celebes Sea (inatews.bmkg.go.id)). Event identification and manual and careful picking are crucial things to get good quality before doing the next step. The local earthquake event that has been picked must be located and then relocated to get the precise hypocenter before using it to run seismic tomography.

4. CONCLUSION REMARKS

We have conducted data acquisition and processing to analyze seismicity around Mt. Merapi by applying a very dense seismic network for a year long recording. Our preliminary results show the basic processing to analyze the signal to identify the earthquake events. Later on, we are going to determine hypocenter location and seismic tomography inversion to invert for seismic velocities (Vp, Vs, and Vp/Vs). We will show more detailed information during the meeting.

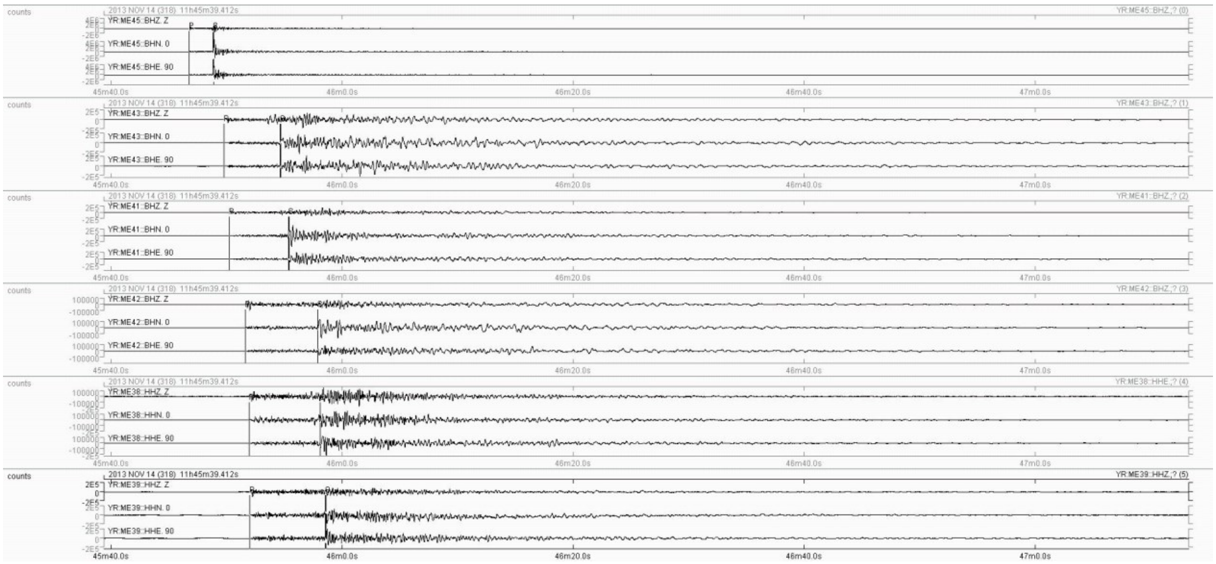

Figure 3: An example of local earthquake waveforms (3-components) for one event that was recorded by DOMERAPI network.

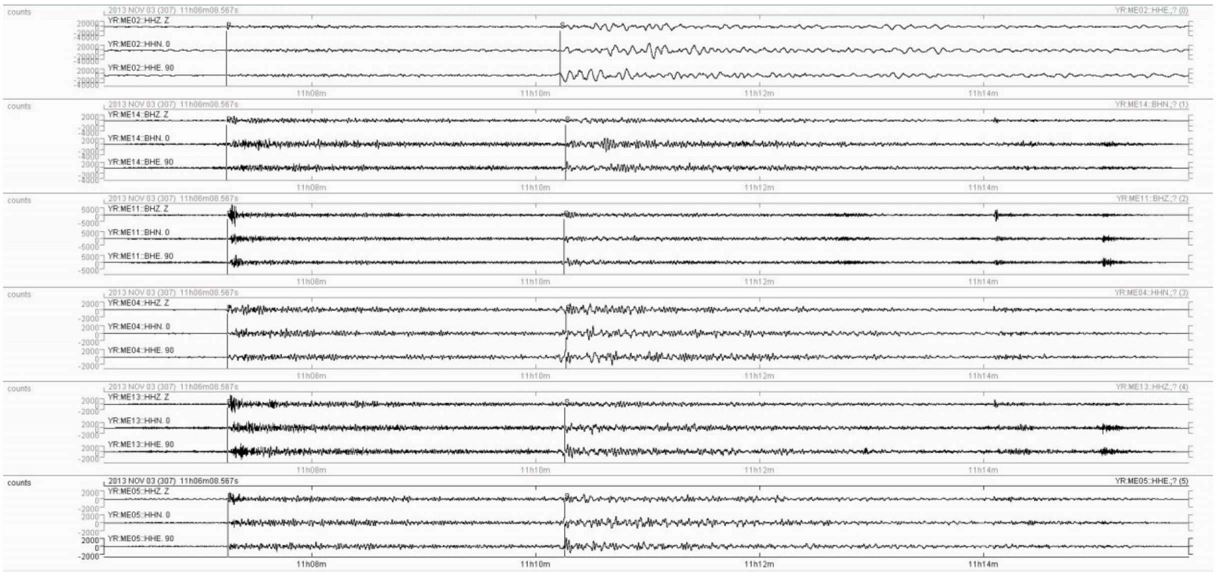

Figure 4: An example of regional earthquake waveforms (3-components) for one event that was recorded by DOMERAPI network.

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