Geophysical Research Abstracts
Vol. 20, EGU2018-12915, 2018
EGU General Assembly 2018

Structure of Merapi-Merbabu complex, central Java, Indonesia, modeled from body wave tomography

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Merapi volcano is known for its frequent activity and dangerous eruptions. The 2010 eruption, the largest in more than 100 years, forced the evacuation of about one million inhabitants and caused 347 fatalities. This eruption was characterised by vertical eruptive columns up to 17 km altitude and pyroclastic flows that extended up to 16 km. Recent petrological studies conclude that transitions from effusive dome growth to explosive and gravitational dome destruction as observed during 2010 eruption are related to volume and depth of magma intrusion. Characterization of the magma storage regions is therefore a matter of fundamental importance in order to better understand eruptive processes of dome-forming type volcanoes.

Previous studies of the structure of the Merapi-Merbabu complex have been performed through data of the MERAMEX experiment completed in 2004. The DOMERAPI project (2013-2017) was aiming to investigate the deep structure of Merapi by increasing the density of observations to improve the resolution and try to differentiate several hypothetical magma storages identified by petrological studies.

A dense network of 46 three–components seismometers has been deployed for 18 months over Merapi-Merbabu complex in order to record the local and regional seismic activity. This network has been complemented by stations from the BMKG, at regional distances and by the stations from CVGHM installed close to the summit and dedicated to the monitoring of Merapi. A total of more than 70 stations are involved in this study. During this period, 545 earthquakes were recorded. In total, we used 35392 phases (20812 P and 14580 S phases) for source location and tomographic inversion.

We performed the tomographic inversion for the Merapi-Merbabu region using all available travel-time data. Inclusion the data of the dense DOMERAPI network has considerably increased the resolution in the upper crust beneath Merapi. In the shallow sections beneath the volcano, we observe higher P-wave and lower S-wave velocities resulting at very high Vp/Vs ratio. This anomaly, which is probably associated with the uppermost magma reservoir, is traced down to the depth of 5 km below sea level. In the deeper sections, we do not observe any clear Vp/Vs anomaly, although the resolution of the model in these parts is sufficient. The deeper magma sources are detected using the regional-scale MERAMEX data and are traced as low-velocity anomaly connecting the slab with the lower crust beneath Merapi. We conclude that the major sources of the present eruption activity of Merapi is related to the shallow source, which is clearly detected in the new high-resolution tomography model.