Combination Model of Spherical Source and Block Movement for Ground Deformation Analysis Prior to the Eruptions in 2006 and 2010 at Merapi Volcano

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Abstract

Dominant southward ground deformations at Merapi volcano (Central Java, Indonesia) were detected by Electronic Distance Measurement (EDM) prior to the eruptions in 2006 and 2010. Slope distances were measured toward 12 reflectors installed near the summit from 5 Post Observatories every day. The slope distance shortened 0.03 - 4.4 m for 7 months before the eruption in 2006 and 0.02 – 3.8 m for 16 months before that in 2010. All of the Change of Slope Distance (CSD) at S sector were much larger (3.4 – 4.4 m) than the other sectors (0.03 – 0.5 m) before the eruption in 2006, and the dominance of CSDs before the eruption in 2010 on the S sector (1.1 – 3.8 m) to the other sectors (0.02 – 0.06 m). The deformation was modelled by combination of a Block Movement (BM) and a spherical pressure source. BM model was applied on the S sector. BM vectors for the first stages (Sept. 2005 to Feb. 2006) before the eruption 2006 was directed to SW, then moved to SE in second stage (Feb. – Mar. 2006), which continued until the appearance of the lava dome. In the 2010 eruption, the block movement vectors moved to SE constantly from beginning of deformation until the explosive eruption on 26 October 2010. After removing BM effect on S sector, a spherical pressure source model was applied to the CSDs on the all sectors. CSD data in 2006 were divided into six periods by CSD rate and CSD data in 2010 were divided into 10 periods. Theoretical ground deformation was calculated by Finite Element Model (FEM), considering steep topography near the summit of Merapi. The spherical source prior to the eruption in 2006 is located beneath of the summit at a depth of $1.0 – 1.1$ km (bsl), while prior to the eruption in 2010, the pressure sources located at a deeper part ($2.0 – 3.0$ km bsl) in NE of summit. The magma volume estimation prior to the eruption 2010 (127.1 million m^3) is larger than the eruption 2006 (10 million m^3) and the difference consistent to eruption material volume that are 130 million m^3 and 12 million m^3, respectively.

Key words: Merapi volcano, Finite Element Method, Block Movement, topographic effect, Change Slope Distance, Spherical Pressure Source, Ellipsoidal Pressure Source