Combination of a pressure source and block movement for ground deformation analysis at Merapi volcano prior to the eruptions in 2006 and 2010

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Abstract

I analyzed ground deformation prior to the eruptions in 2006 and 2010 at Merapi volcano, Central Java, Indonesia. The ground deformation was monitored by electronic distance measurement (EDM) by measuring the slope distances toward 12 reflectors installed near the summit from five benchmarks on flanks every day. A large change of slope distance (CSD) was detected on the southeast and south baselines and a minor CSD was detected on the north and northwest baselines during the pre-eruptive stages of both the 2006 and 2010 eruptions. I applied a block movement model to the south and southeast baselines and a spherical pressure source model to the CSDs on the north and northwest baselines using the finite element method (FEM). The rates of block movement southward and the volume change of the pressure source increased on April 7, 2006 and continued at constant rates until the appearance of a new lava dome on April 26. Prior to the eruption in 2010, the block movement southeastward and the volume increase of the pressure source accelerated in the middle of October, and acceleration continued until the first outburst on October 26, 2010. Temporal patterns of the block movement and the increase in the volume of the pressure source correlate well with the increase in seismicity of volcano-tectonic (VT) and multi-phase earthquakes. The pressure sources were obtained at a depth of 2 ± 0.5 km below the summit, and this position corresponds to aseismic zone of VT earthquakes. Magma injection at the shallow part of this region causes an increase in the volume of the pressure source, and inflation of the

ground of the summit triggered gravitational slip southeastward or southward of the ground surface. The volumes increases of the pressure sources were 9.7 ± 1 M m^3 and 17.6 ± 0.8 M m^3 in 2006 and 2010, respectively. The volume increase is related to the scale and type of the eruption. The effusive eruption in 2006 had a volcanic explosivity index (VEI) of 2 and the explosive eruption in 2010 had a VEI of 4. The directions and amounts of the block movement are strongly related to the topography, hydrothermally weak zone and underground gap near the summit between West and East Domes.