

Eruption Mechanism of Explosive Eruption at Semeru Volcano, East Java, Indonesia

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Semeru volcano is the most active volcanoes in Java. Summit of the volcano is Mahameru with the elevation of 3676m. Southern part of the summit grows the young active crater (Jonggring Seloko crater) which has been erupting since the 19th century. Small vulcanian explosions with plume height less than 1000 m have occurred at intervals of between 5 minutes to one hour. The eruptive activity has continued since 1967.

We conducted temporal observations with broadband seismometers, tiltmeters, infrasonic microphones infrared scanner, video and Differential Optical Absorption Spectrometer (DOAS) for measurement of gas emission rate in July 2005 and November 2006. Broadband seismometers, tiltmeters and infrasonic microphones were installed at Mahameru, 700m away from Jonggring Seloko crater. The tilt records show inflation prior to explosions and deflation associated with the explosions. The inflation tilts appeared 5 to 30 minutes before the explosions and the tilt changes range 1 to 10 nradians. The inflation-deflation patterns are detected for all the explosions and are similar to those detected by water-tube tiltmeter at Sakurajima and broadband seismometers at Suwanosejima volcanoes in Japan. Explosion earthquakes are accompanied with explosive eruptions. The explosion earthquakes begin with upward first motions and followed by dominant Rayleigh waves. Dominant horizontal component of the first motions suggest quite shallow depths of the hypocenters of explosion earthquakes. Displacement seismograms obtained from broadband seismograms show expansion and contraction process of the source. The expansion process continued for 2 s and the turning to contraction coincides with the start of eruption as detected by infrasonic records. Contraction volume is estimated to be 300m³ and it is almost similar to the volume of gas emission estimated by DOAS observation. These facts suggest that inflation detected by the tiltmeter and deflation by the tiltmeter and the broadband seismometer are caused by accumulation of volcanic gas at the uppermost part of the conduit and release of it.

Tiltmeter also detects quite interesting phenomena. Tilt record shows minor downward tilt 3s before the beginning of expansion corresponding to the P-wave first motion of explosion earthquake. This indicates that minor contraction and minor expansion occur before major deflation, which corresponds to eruption. We infer the following process of volcanic explosion at Semeru volcano. (1) Volcanic gas is accumulated at uppermost part of the conduit causing inflation tilt 5 to 30 minutes before explosions. A gas pocket is formed. In this stage, the top of the conduit may be plugged because no plume is visible and significant SO₂ is not detected by DOAS. (2) Associated with accumulation of volcanic gas, pressure of the gas pocket increases. When the pressure exceeds the threshold level of strength of the plug, weak gas emission occurs. This corresponds to minor contraction detected by tiltmeter. (3) Weak emission of volcanic gas induces decrease in pressure of oversaturated magma beneath the gas pocket and sudden growth of gas bubble occurs in the magma. The sudden growth of gas bubble cause expansion process estimated from upward P-wave first motion of explosion earthquake. (4) Sudden expansion destroys the plug at the top of the conduit, emitting infrasonic wave. After removal of the plug, volcanic gas and ash are ejected, causing deflation tilt. Major inflation-deflation pattern and minor deflation and inflation at the turning from major inflation to deflation are also detected at Sakurajima and Suwanosejima volcanoes.