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Volcanic eruption mechanism at Semeru volcano, Indonesia

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Semeru volcano (3676m asl) located in East Java, Indonesia has repeated Strombolian-Vulcanian eruption at Joggring Seloko crater at the summit and lava tongue is sometime formed in the crater and pyroclastic flows are generated due to collapse of it. Time interval of Strombolian eruption ranges 10 minutes to 1 hour and height of volcanic plume attained 1km high above the crater.

Inflation of the ground around craters are detected prior to explosive eruptions at Sakurajima and Suwanosejima volcanoes and the inflation turns deflation after the beginning of explosive eruptions. Volcanic explosion is initiated by isotropic expansion at a depth of 2km and surface explosion at the crater is followed 1 second after. At Suwaonsejima, seismogram shows that contraction at a depth of 300m occurs at first and temporary expansion succeeds. Relation of the two phases in seismogra with eruptive phenomena has not been made clear. In this study, we conducted comprehensive volcanic observation in order to detect inflation-deflation pattern associated with individual explosions at Semeru volcano and to make clear relation of seismic phases with eruptive phenomena.

Directorate of Volcanology and Geological Hazard Mitigation monitors eruptive activity by permanent seismic stations 8km east and 10km south of the crater. We installed an array of 3 broadband seismometers (STS-2) , tiltmeters (AG701) and infrasonic microphone, 700-800m north of the crater. The seismic, tilt and infrasonic signals were recorded in data loggers (LS-7000XT, 24 bit resolution, 200 Hz sampling). In addition, visual observation by infrared scanner and TV camera was conducted at a point 8 km south of the crater and measurement of SO2 emission rate was done by DOAS from the northern flank. The timing system of recorders of the images was calibrated by GPS. We conducted the observation from 12h on July 5, 2005 to 6h on July 7, and 150 explosion earthquakes were recorded.

We obtained displacement seismograms for analysis. Initial motions of the explosion earthquakes are compression and are composed of P-wave. Particle motion diagram indicates shows that the following larger waves are composed of Rayleigh waves. We show an example of analysis for explosion earthquakes at 05h53m on July 7. The first motion was initiated at 05h53m29.62s. The first motion was moved upward in vertical component and north (outward from the crater). The amplitude of radial component is 5 times larger than vertical one and the hypocenter of the explosion earthquake is quite shallow, may be 100 m. The upward and outward motion turned downward and inward to the crater, respectively, at 32s, 2 seconds after the first motion and the inward motion continued for 10 seconds. By comparing with source mechanism analysis at Sakurajima volcano, it is interpreted that the explosion earthquake was initiated by expansion for 2 seconds and turned contraction. The occurrence times of the 2 phases (initial motion and beginning of contraction) are compared with eruptive phenomena. Volcanic ash cloud appeared at 33.8 s as recorded by TV camera and infrared scanner. Arrival time of shock wave generated by eruption is 34.36 s at a point of 700 m from the crater. Origin time of the shock waves is estimated to be ca. 32s from distance from the crater and sound velocity (335 m/s, 5 degree). Lag time of the appearance of ash cloud from the shock wave is due to depth of the crater. The arrival time of the initial motion is 2 seconds earlier than origin time of shock wave. It is inferred that internal expansion process continues for 2 seconds at the crater bottom without surface phenomena. The starting time of contraction coincide with origin time of shock wave. The contraction is caused by ejection of volcanic gas and ash.