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Analyses of Flashing arc on Izu-Oshima 1986 eruption based on 3-D numerical simulation of blast waves with the topographic effect

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The flashing arc is one of the pressure wave phenomena caused by volcanic explosions.

It is observed as the temporal appearance of cloud due to phase change of the atmospheric vapor associated with the rapid pressure change behind the volcanic blast waves.

This phenomenon brings us useful information about the pressure field near the explosion source. Nairn (1976) and Ishihara (1985) estimated the pressure of the explosion source from the propagation velocity of the flashing arc using the amplitude-velocity relation of the one-dimensional shock wave theory. On the other hand, Yokoo et al. (2002) noted that the essential nature of the pressure wave producing the flashing arc is ascribed to the spatial expansion of the wave. They investigated the time-space distribution of the region where clouds may be formed based on the numerical solutions for explosions of a high-pressure sphere. Their results demonstrated that making use of the time-space structure of the clouds as well as its propagation velocity enable us to determine the pressure and the size of the explosion source. They applied their method to the flashing arcs observed in Izu-Oshima 1986 eruption so as to determine the source parameters of the explosion.

On the other hand, propagation of blast waves induced by volcanic explosions have been investigated by using 3-D numerical simulations considering the topography at the Shock Wave Research Center, Institute of Fluid Science, Tohoku University. The numerical studies have revealed that blast waves reflect at the complex terrain and change their strength and structure. It is, therefore, important to take the real ground shape as accurately as possible in the numerical simulations. Reviewing the analyses by Yokoo et al. (2002) from this aspect, it is not obvious if the solution of the spherical explosion is comparable with the observed flashing arcs. In the present study, we conduct 3-D numerical simulations for the propagation of blast waves at Izu-Oshima volcano and re-evaluate the source parameters of the explosion by comparing the numerical solutions and the observation.

The topographic map with 5-m altitude contours drawn during the 1986 eruption at Izu-Oshima is used to construct the ground surface mesh with 2-m intervals. The final 3-D volume meshes cover the area of 200 m by 200 m and the altitude of up to 160 m above the lava-lake surface. The number of grid points used is 800,000 (100 x 100 x 80).

We assume a spherical bubble containing high-pressure and high-temperature H2O vapor as the explosion source. We put the sphere at the surface of the lava lake and release the gas at the instant when the calculation starts. The conditions (pressure, temperature, and water content) of the surrounding air are set as those of the atmosphere above Izu-Oshima volcano at that time. The partial pressure and the saturation pressure of H2O vapor are calculated from the pressure and the temperature obtained by the numerical calculation, respectively. The clouds are regarded to be formed in the region when the partial vapor pressure exceeds the saturation pressure. The time-space distribution of the clouds is obtained for each set of the source parameters, which are the radius of the sphere and the pressure and the temperature of the internal gas. The solutions are compared with the video records on the flashing arcs taken on November 21st., 1986, and the most adequate source parameters for the explosions are determined. Furthermore, the present solutions are compared with the previous spherical explosion model and the effects of the ground surface are discussed.

The present method, which determines the explosion source parameters by combining the image analyses of the flashing arcs and the numerical simulations of the blast waves, is expected to be more and more useful with the development in the image technology. We are developing this method to establish a new measurement system for volcanic explosions.