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An Experimental study on the process of pressure release and pyroclastics ejection on volcanic explosion

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The velocity of ballistics and the intensity of air wave have been thought to reflect the pressure on volcanic explosion. However, the pressure evaluation based on the ballistics and air wave analyses (e.g. Iguchi,1983, Meghan, 1997) sometimes disagree with each other, mainly due to the incomplete understanding of the relationship between the explosion condition and the resultant surface phenomena. To understand it, field explosion experiments using dynamite (e.g. Ohba et al., 2002) and laboratory explosion experiments using high-pressure gas with sand (Goto et. al.,2005, 2006) have been conducted. In the present study, we focus on the effect of the sand grain size on surface phenomena in the laboratory explosion experiments to know the interaction between energy source gas and volcanic ejecta.

The apparatus consists of a chamber that saves and releases high pressure gas, and a one-meter cubic container surrounding the chamber. Inner diameter and depth of the chamber are 50mm. Diameter of vent on the top of the chamber are 10, 20, 30, or 40mm. The rupture of the diaphragm at the vent released the gas rapidly from the chamber to blow the well-sorted sand covering it up. The thickness of the sand layer are 27 or 64mm, the initial differential pressure in the chamber are 0.25 or 0.51MPa against atmosphere, and grain sizes are 0.4 or 0.8mm on each experiment. The sand motion is recorded using high-speed camera. The pressure changes inside and outside the chamber are also recorded. These three data are synchronized through common trigger signal. Below we mainly focus on the change of surface phenomena against vent diameter and grain size, because they are relatively insensitive against sand thickness and initial pressure.

In all experiments, decompression in the chamber progressed smoothly from the start to the end of the gas release. A pulse and following air wave, those may correspond to diaphragm-rupture and following gas ejection, respectively, were observed outside the chamber.The pulse was weak when the vent diameter was small and grain size was small. The air wave was single and strong with long period when the vent diameter was large, while a weaker long-period wave and following strong and short period multiple wave were observed when the vent diameter was small. Air wave tended to be stronger when the grain size was small. The large vent formed dome-like sand column whose ascent velocity decreased with time.To the contrary, sand column from small vent ascended as dome-like in initial, then changed to tulip-like shape; which formed as if the dome was broken from inside by the following gas flow from below. Ascending sand column accelerated at this time and resultantly got higher velocity compare to that from larger vent. The record of chamber pressure confirmed the gas release from small vent continued until the decline of the multiple waves, and sand column started to be accelerated with the beginning of the multiple waves. This may mean that few amount of gas firstly reached sand surface to generate the initial long period wave and form the effective degassing path in sand layer, then passed the rest gas through the path to generate the multiple wave and accelerate the sand column simultaneously.

These results suggest that the interaction between high pressure gas and ejecta controls the surface phenomena significantly on volcanic explosion. This is also supported by the fact that on the experiments with smaller sand that higher interaction with gas is attainable, ascent velocity of sand column was faster, and the generation of the first air wave delayed.

As a remark, on volcanic explosion the easiness of gas release could be influenced by the vent diameter and the properties of substances filling the vent. And in case the gas release is not easy, the initial pulse generated by explosion could be small, while the velocity of ballistics could be accelerated to be fast during ascent by two-step gas release.