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Analogue experiments of volcanic explosions using high pressure gas - part 3: ejecta motion analysis -

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In the Field Explosion Experiments using dynamite as an analogue of volcanic explosion, we have found that scaled depth, which is the depth divided by cube root of energy, is the main parameter determining the properties of explosive volcanism (Goto et al., 2001, GRL; Ohba et al., 2002, JVGR). On the other hand, Laboratory Explosion Experiments, which simulates volcanic explosion by releasing high pressure gas to the bottom of sand, has showed that the property of blown-out sand motion and formed crater diameter change against conduit/vent diameter ratio and gas pressure systematically even when the total gas energy and the sand depth are the same (Goto et al., Japan Geoscience Union Meeting 2005; Volcanological Society of Japan fall meeting 2005). The latter results indicate that the scaled depth is not the only parameter controlling the properties of volcanic explosion: it is important to consider the influence of energy release rate. As the first step to model these effect on volcanic explosion, we analyzed the sand motion using high speed video images obtained from the Laboratory Explosion Experiments.

The apparatus consists of a chamber that accumulates and releases high pressure gas, and a one-meter square container which has the chamber on the bottom of it. The breakage of diaphragm by a firing pin releases the high pressure gas. Inner depth of the camber is fixed to be 50mm, and the inner diameter is 10-50mm with 10mm interval. To achieve the half volume of the 50mm-diameter chamber, the camber with 35.36mm inner-diameter is also used. Platy rings hold the diaphragm on the top of the chamber, and the inner diameter of the rings ranges on the same way as those of the chamber. The sand depths are 8, 26 and 64mm, and the differential pressure in the chamber against atmosphere is 1.25-7.50atm. The gas energy is defined as the product of volume and pressure. The sand motion is recorded using high-speed video camera (nac K3) by 1000fps. The pressures inside and outside the chamber are also recorded.

The shape of sand column formed by explosion are largely classified into three: funnel-shaped corn type, tight-top jet type, and intermediate egg-like bell-shaped column. The corn type jet is achieved when the inner diameter of the platy ring is much smaller than that of the chamber, resulting in slow decompression in the chamber by choking. When choke is achieved, vertical velocity of the column top, vertical and horizontal velocities of the widest part of the shape are extremely higher than another cases. In case of no-choke mode, the following features are observed:

1. Vertical velocities of the top and the widest part of the column become high as the vent diameter becomes small. Contrary to this horizontal velocity of the widest part is almost independent of the vent diameter. These results indicate the column shape is mainly controlled by the vertical velocity of sand particles.
2. When the product of volume and pressure of gas (i.e., energy) is the same, higher pressure makes the sand velocity higher.
3. Larger vent produces lower sand velocity and higher shock wave pressure.

These indicate the energy release rate changes the properties of the surface phenomena on volcanic explosion, even when the depth and energy of explosion, i.e., scaled depth, are the same. Among the above three features, the last one seems to be interesting from the view point of energy partition. Nishimura and Uchida (2005, Bull. Volcanol. Soc. Japan) analyzed the explosion earthquakes of Asama 2004 eruption, and revealed that the gas pressure on Sep. 1 eruption was the lowest among the successive eruptions, although the observed air wave pressure was the highest. This may be the result of relatively low pressure gas rapid release.