Analogue experiments of volcanic explosions using high pressure gas

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Field explosion experiments, analogue experiments of volcanic explosion using dynamite, had been carried out to know the relationship between explosion condition (i.e., energy and depth) and resultant phenomena such as crater size, ballistics distribution, blast pressure and seismic energy, to construct a scaling rule on volcanic explosion. Through the series of experiments it was concluded 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). By applying this result the explosion condition such as depth and energy of explosions on Usu 2000 eruptions was estimated (Yokoo et al., 2002, GRL).

However, volcanic explosion seems to be quire different from that by dynamite on pressure and duration; explosion pressure of dynamite and volcanoes are a few tens of thousands bar and a few - a few hundreds bar, respectively. The influences of such discrepancies are unclear, and resultantly the applicability of the results by field explosions experiment to volcanic explosions is not self-evident. For this reason we have started laboratory explosion experiments using high pressure gas release, which can control initial pressure and energy release rate.

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. Inner diameter and depth of the chamber is 50 and 80 mm, respectively. When the pressure is few bars, the gas is sustained by single diaphragm on the top of the chamber. Breakage of diaphragm for high pressure gas release is possible in two ways; forced breakage by a firing pin, or self breakage by growing the gas pressure gradually. The chamber inner size and vent radius is changeable by inserting cylindrical or platy spacer in the chamber and changing diaphragm holder ring, respectively. A pressure sensor is inserted in the chamber to monitor the pressure decrease and to determine the breakage time.

The chamber is covered with sand, and emits high pressure gas rapidly. Crater diameter, high speed video image and blast wave are recorded to relate the resultant surface phenomena with pressure, chamber diameter, crater diameter and sand depth.

The present experimental results showed that surface phenomena is not necessarily determined by scaled depth. When the sand depth, chamber depth and gas pressure are constant, scaled depth is determined by gas volume, and resultantly the chamber inner diameter. We observed the shape of explosion column was changed by the vent diameter even when the chamber diameter was the same. For example, when the sand depth, chamber depth and gas pressure (differential pressure against atmosphere) are 26 mm, 30 mm and 3 bars, respectively, 30 mm diameter vent produced a bell-shaped explosion column, although 11 mm vent produced a narrow funnel-shaped one. Vertical growth rate of the column was large on the latter one. The experiments with other inner diameter showed the same tendencies.

From equation of motion, it is clear large velocity is attainable by long acceleration time. The above result may be due to the differences in decompression time in the chamber that controls acceleration duration of the sand particle.

The present results show that some energy-transmission efficiency from high pressure gas to ejecta, such as energy release rate and gas/particle relative velocity, should be considered to discuss ejecta trajectory. Although there exist some models which estimate explosion pressure from ejecta velocity (e.g., Wilson, 1980, JVGR), it is not clear which model is most plausible. Further experiments will make clear the relationship between explosion condition and resultant surface phenomena more quantitatively.