Laboratory geyser; Insights into predictability of mass and style of eruptions

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The time predictability of geysers implies that the mechanism of mass and energy conservation works in the simplest manner. Even in such a simplest case, the mass predictability is quite difficult. Thus, in the present study, in order to obtain insights into factors controlling mass and style of geyser and volcanic eruptions, we conducted laboratory experiments of geysers in which the time-predictability is reproduced. In the series of experiments, we measured pressure and temperature in a hot water chamber, flux from a cold water reservoir, and mass erupted by events (total number of eruptions are up to 100), varying experimental conditions such as the heating rate, water quality, and system geometry. We observed two styles of eruptions, "jet" and "flow" depending on the maximum height of erupted water reached. Based on the statistical analysis of the erupted mass, an experiment setup that produces only jet events exhibits a narrower frequency distribution of the erupted mass with a relatively large average. In the experimental setup in which flow events occupied increasing proportions, the frequency distribution of the erupted mass widens with relatively small average mass. The temperature measurements indicated that jet-dominated experimental setups had smaller temperature fluctuations than flow-dominated setup. In order to understand these correlation among temperature fluctuation, mass and style of eruptions, we propose a model including a triggering condition and eruption condition using a Monte Carlo simulation consisting of 256x256 parcels with temperature as a stochastic variable by a Gaussian probability density function (PDF). The triggering condition (the gas volume in chamber under hydrostatically over-pressured state exceed the volume of the vacant conduit) gives a constraint on the average and variance of PDF by an inverse manner. The eruption condition defines two types of parcels with two thresholds of eruption potential according to hydrodynamic energetics; explosive parcel and eruptive parcels. The results showed that when the PDF has a larger average and smaller variance, the event tends to be explosive and large fraction of water is evacuated, as in jet events. Decreasing the average temperature or increasing the variance of the PDF shifts the events to an explosive style followed by an effusive event and to an event that produces only effusive flow. This transition of eruption styles from explosive to effusive and the relationship with the erupted mass is consistent with results of the laboratory experiments. Applying this results to volcanic systems, we speculate that an uniformly supersaturated chamber produces a large plinian eruption whereas a chamber with a highly heterogeneous supersaturation produces the lava flow remaining a large un-erupted mass in chamber. Intermediate heterogeneity of chamber supersaturation produces a plinian followed by equivalent mass of lava flow event like in typical andesitic volcanoes.