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Possibility for mass-predictability in an experimental geyser

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Geysers are the periodical eruption of hot water and steam, and have the similarities with volcanoes for various aspects, especially in the seismic behavior precursor eruption [Kieffer, 1984]. It has been well known that natural geysers are a time-predictable system [Kieffer, 1984; Nishimura et al., 2006]; we can approximately predict the onset time of next eruption by preceding duration time which represents erupted mass, by utilizing the regular positive correlation between the duration of eruption and interval from the last eruption. Thus, erupted mass is a key factor for the prediction. So, if we can predict the erupted mass or give some constraints on it, then we can obtain a big possibility to the perfect predictability of geyser eruption. However, it is still unclear what kinds of parameters control the next erupted mass. In order to find parameters to control erupted mass, using geyser experiments which can reproduce the time-predictability we carried out directly observed the interior invisible in nature and eruption styles and measured the physical variables associated with the similar natural phenomena. The simple experimental setup used consists of a heater (hot plate), flask, glass tubes, and water tank. We automatically measured the mass of erupted water for about 80-100 eruptions and the period (the time interval between onsets of sequential eruptions) by using the electronic balance connected to PC with varying experimental parameters. We also measured the pressure and temperature of water in the flask and temperature of hot plate. Observing the eruption styles in the experiments, we found two fundamental types of eruptions; "Jet" (vigorous spout of hot water from the vent) and "Outflow" (the flow of hot water from the vent without splash). From experiments, we obtained following results; (1) a condition whether "Jet" occurs or not is controlled by the efficiency of heat transfer from the hotplate to water in flask . Namely "Jet" happens more frequently when the efficiency of heat transfer is relatively large. (2) there is a positive correlation between periods and the mass of water erupted by preceding eruption (i.e., time predictable system) as expected, (3) the distribution of erupted mass is typically Gaussian when the "Jet" is a dominant style whereas it is a white noise like distribution when "Outflow" is a dominant style, (4) The range of values of erupted mass is broad in eruptions for which the power of pressure fluctuation (we call this "PPF") during the last period is large, otherwise the erupted mass converges to narrow range in eruptions in which "PPF" is relatively small. From these results, we can expect the correlation among erupted mass, eruption styles and the "PPF" of preceding eruption. Taking into account the experimental result (1) ,(3) and (4), we can infer that PPF might be a quite sensitive indicator of the efficiency of heat transfer which delicately changes with time even in a single set of experiment with fixed values of parameters. It is important that PPF can be measured by an instrument in experiments but the efficiency of heat transfer is difficult to be determined experimentally due to not only the efficiency of heating from the hotplate but also the complex water flow within the system including the conduit and reservoir connecting the flask.Thus, it is concluded that the "PPF" may become the key value for mass-predictability in the experimental geyser.

Keywords: geyser, experiment, volcano, prediction, hot water, erupted mass