Experimental study on precursory pressure oscillation in the experimental geyser system

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Geysers exhibit characteristic behaviors such as precursory seismic events, time-predictability, and periodicity. They have similarities to volcanos in seismicity, so understanding the seismic events of geysers may provide potential insights into volcanic tremor. It is known that pressure pulses inside the water column of geysers trigger the tremor. However, the origin of the pressure pulses is still unclear. The phenomena of natural geysers are complicated and difficult to observe directly, so laboratory experiments may be useful to understand natural geyser system. In this study, we try to reveal the origin of the pressure oscillation inside the geysers using laboratory experiments.

We conducted two experiments: experiment 1 and experiment 2. In experiment 1, we used an analog experiment (basically same one documented by Toramaru and Maeda (2013)), which reproduces the natural geyser; the flask corresponds to the hot water chamber, the glass tube to the geyser conduit, the cooler water reservoir to the inflow of ground water and the hot plate to the geothermal heat.We measured pressure and temperature in the flask and took normal speed and high speed videos of the flask interior and the surface of water in a glass tube, thereby we examined the relationship between the phenomena taking place in the flask and the conduit, and the fluctuation of pressure. In experiment 2, in order to reproduce bubble formation caused by boiling, we designed an experimental setup which is capable of injecting air into the flask filled with water. Using this experimental setup, we measured pressure in the flask and took videos of behavior in the flask and at the surface of water to observe the pressure fluctuation like tremor, with varying experimental conditions such as injection amount (the amount of air injected into the flask), the injection rate (the amount of injected air par unit time), and initial water level (the level of water head in the conduit).

From the results of the experiment 1, it is found that (a) a bubble formation in the flask cause a pressure pulse and a subsequent damped pressure oscillation, (b) the amplitudes of the pressure pulses have positive correlation with the diameters of bubbles. From the results of the experiment 2, we find that (c) an air injection into the flask causes a pressure pulse and a damped pressure oscillation similar to result (a), (d) the pressure oscillations in the flask attenuate by the coupling with the fluctuation of water level in an opposite phase, (e) the amplitudes of pressure oscillations have positive correlations with the injection rate and initial water level, (f) the frequency of damped pressure oscillation has negative correlation with initial water level and no correlation with injection rate. Considering the result (a) and (c), it is suggested that the pressure oscillations are induced by additions of fluid (in this study, they are bubble formations by boiling and air injections) to the flask interior, and from the result (d), it seems that subsequent damped pressure oscillations are caused by the vertical movement of upper water column.

In conclusion, the pressure oscillations in the flask are induced by additions of fluid to the flask interior, and then attenuate by the coupling with the fluctuation of water level. Their amplitudes have positive correlation with the bubble diameters, injection rate and initial water level, and their frequencies has negative correlation with initial water level.

