

Experimental study on precursory pressure oscillation in the laboratory geyser system: Its frequency change and mechanism

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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 tremors which are important signals in forecasting forthcoming eruptions.

Kedar et al. (1996) suggested that pressure pulses inside the water column of geysers trigger the tremor. Toramaru and Maeda (2013) reproduced eruptions and internal pressure oscillations of natural geysers using the laboratory geyser system. Teshima and Toramaru (2017, JpGU), using the almost same experimental setup, suggested that (a) a bubble formation in the flask cause a pressure pulse whose amplitude has positive correlation with the diameter of formed bubble and (b) the frequency of pressure oscillation decrease systematically from the end of eruption to just before the next eruption. In the present study, we try to reveal the mechanism of the pressure oscillation and factors controlling its frequency change.

We conducted experiments using the setup 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 source of ground water and the hot plate to the geothermal heat. We measured pressure and temperature in the flask and took video images of the flask interior and the water surface in the glass tube, by normal speed and high speed video cameras. Furthermore, we conducted experiments changing 3 parameters: (i) the temperature of the hot plate, (ii) the height of the water column in the glass tube and (iii) the barrier of bubble nucleation on the bottom surface of the flask (presence or absence of olivine sands to assist bubble nucleation). We examined the relationship between the phenomena taking place in the flask, vertical movement of the water column and the pressure oscillation.

From the results of the experiments, we found that (a) the pressure fluctuation and the vertical movement of water column are inversely correlated and (b) the temporal behavior of their characteristic spectrums nearly coincides. The fluid-system oscillation model (suggested by Toramaru et al., 2010, VSJ), indicates that the ratio of the amplitude of pressure oscillation to that of movement of water column equals the combination of effective bulk modulus and volume of the fluid in the flask and the cross-sectional area of the conduit. Applying the model, it is found that the systematic frequency decrease in pressure oscillation can be explained by the decrease in effective bulk modulus of the fluid in the flask.

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