Multi-parameter observations at Shikabe geyser and unique changes in interval between eruptions

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Geyser is a hot spring characterized by periodical spouting of superheated water together with steams or non-condensed gases. Since the physical processes of eruption of steam and hot water are similar to those of volcanic eruption, geysers have been studied as an analogy of volcanic eruption.

One of the major features of geyser phenomena is Interval between eruptions (IBE). IBEs are different for each geyser and have a wide range from a few minutes to several hours. Furthermore, a geyser sometimes has more than one constant IBE. For example, El Cobreloa geyser in El Tatio, Chile, repeats several small eruptions approximately every 14 minutes and followed by large eruptions lasting about one hour with a repeating period of about four hours (Namiki et al., 2014), and some geysers in Yellowstone National Park, United States, have changed the IBEs for long periods, which seem to be influenced by precipitation and river discharge (Hurwitz et al., 2008). However, there are few quantitative studies focusing on the mechanism of such IBE changes.

The Shikabe geyser in southern Hokkaido was discovered through the development of hot springs in 1952. It is a large geyser erupting more than 10m and haves a relatively short IBE about 12 minutes After the field experiments conducted by Otani in 1961 (Otani, 1961), any physical observation had not been carried out to this day although the eruption characteristics, such as IBE, eruption height and discharge volume, might have changed since then. Therefore, in this study we started multi-parameter observations using some physical monitoring instruments at the Shikabe geyser in order to obtain new knowledge on the phenomena associated with the geyser eruption and to understand the mechanism of IBE change. Since IBE of the Shikabe geyser is about 12 minutes, we can collect a lot of field data of spouting events. Moreover, an iron pipe conduit of a known diameter might be an advantage to constrain the geyser’s geometry.

The monitoring contents are video camera, thermal infrared camera, micro-barometer, acoustic sensor, tiltmeter, seismometer, and thermometer. The acoustic sensor and micro-barometer were placed at the same position about 4m from the vent, and the seismometer and tiltmeter were placed at the same position about 6m from the vent. The thermometer has a sensor attached to the vent and measures the temperature of the water when the hot water overflows from the nozzle. Observation started on November 25, 2019, and continuous data recording were made on five instruments except video camera and thermal infrared camera.

We confirmed regular pattern of signals corresponding to eruption and quiescence in the observed data. Micro barogram and acoustic signal show high frequency waves associated with eruption. Temperature signal captured successfully the timing of overflow and recorded the maximum temperature of hot water higher than 100℃. The seismogram contains a quite high frequency component associated with eruption. However, since it greatly exceeds the frequency band widely reported in the observation of volcanoes and geysers, we must check the seismic data carefully. The ground tilt in the transverse direction indicates changes clearly that seem to correspond to inflation and deflation of the reservoir. However, no clear change was observed in the radial direction, which suggests that the aquifer may have a complex geometry.

Our data show that IBE of the Shikabe geyser was not always constant but rather showing characteristic change in time. The average of IBE is about 12 to 13 minutes. IBE sometimes becomes 2-3 minutes longer than the mean interval, and the next IBE is certainly about 1 minutes shorter than the average. Compering the long IBE event with short one, both the quiescence period and the discharge period in one eruption cycle were long in the long IBE event, while both were short in the short one. The occurrence frequency of this characteristic IBE change varies day by day. As a next step, we would like to discuss the cause of this IBE change quantitatively, taking its relationship with weather conditions into account.

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