Intermittent hydrothermal discharge phenomenon observed at the west crater of Iwo-yama volcano, Kirishima Volcanic Complex, Japan

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This study targets the intermittent hydrothermal discharge phenomenon observed at the Ebinokogen Iwo-yama west crater, Miyazaki Prefecture. It was confirmed that the hot water pool of the west crater W4 (Fig. 1) was repeatedly filled and dried from April to July 2021 with a cycle of 17 to 70 hours. There were three vents at W4 and hydrothermal discharge was mainly confirmed from vent Fs. And, hot water drained back to three vents and pool disappeared. In addition, one cycle was as follows. First, hydrothermal discharge from the vent Fs, and it forms a hot water pool and submerging the vents. And, it gradually becomes a steam-dominated discharge. Two hours after the start of hydrothermal discharge, it shifts to only steam discharge phase. And, 17 to 70 hours after the start of hydrothermal discharge, the steam discharge stop completely and the hot water pool dries up. And 20 to 30 minutes later, hydrothermal discharge starts again. This is a phenomenon similar to a geysers activity. Geysers are that eruption of water and steam are separated by clearly defined quiescent intervals. However, this phenomenon in Ebinokogen Iwo-yama is extremely valuable because the phenomenon was suddenly confirmed in an area where the geyser phenomenon had never been confirmed.

Then, we performed multi-parameter observations (camera, thermometer, electric self-potential, seismometer, acoustic sensor, tilt meter) for this phenomenon (Fig. 1). The purpose of this study is to clarify the cause of the hydrothermal discharge. In past studies on geyser activity have considered the cause of eruptions follow as: groundwater accumulates in cavities and conduits in the ground, which are heated by geothermal heat to cause boiling (e. g., Mackenzie, 1811; Bunsen, 1847), or the gas that flows into the ground lifts up the water in the conduit (e. g., Kagami, 2016). However, there are few research examples that mention how long before and how groundwater flows in. In this study, new knowledge has been gained in how the movement of water in the ground affects eruption by analysis of self-potential data, which is one of the observation parameter. Next, the particularly important observations obtained in this study are listed.

First, in the temperature data, it was confirmed that the temperature dropped sharply from about 96 [℃] to 70-80 [℃] when the steam discharge stopped, and the temperature rose sharply with the start of hydrothermal discharge. And, at the start of hydrothermal discharge, it shows a low temperature of 80-90 [℃], but 7-14 minutes after, it around 96 [℃], which is the boiling point at the altitude (1233 m) of the west crater. In addition, it was confirmed from the self-potential data that the fluctuation started about 2 hours before the hydrothermal discharge. However, it was also confirmed that self-potential fluctuated but hydrothermal discharge did not occur. In this case, there was a slight decrease in temperature. These self-potential fluctuations may be due to the streaming potential caused by the movement of water in the ground. Furthermore, in the seismic data, it was confirmed that the seismic energy decreased below the 20 Hz band after the self-potential fluctuations, and that the seismic energy increased sharply in the 5-10 Hz band at the same time as the steam discharge stopped. The change in the seismic energy in these low frequency bands may capture the phenomenon inside the conduit.

From these observations, we considered the causes of hydrothermal discharge as follows. First, cold water flows from the conduit wall into the inside of the conduit connected to the lower part of the fumarole at the same time as the start of self-potential fluctuation about 2 hours before the hydrothermal discharge.

This weakens the boiling of hydrothermal that originally occurred in the conduit before inflow of cold water. And, the inflow of cold water from the conduit wall increases, a large amount of bubbles containing volcanic gas components supplied from hydrothermal may lift up the inflowing cold water and lead to an eruption. In the future, we aim to elucidate the overall mechanism of the intermittent hydrothermal discharge phenomenon by using infrasound and tilt data.

Keywords: Geysers, Intermittent hydrothermal discharge, Electric self-potential

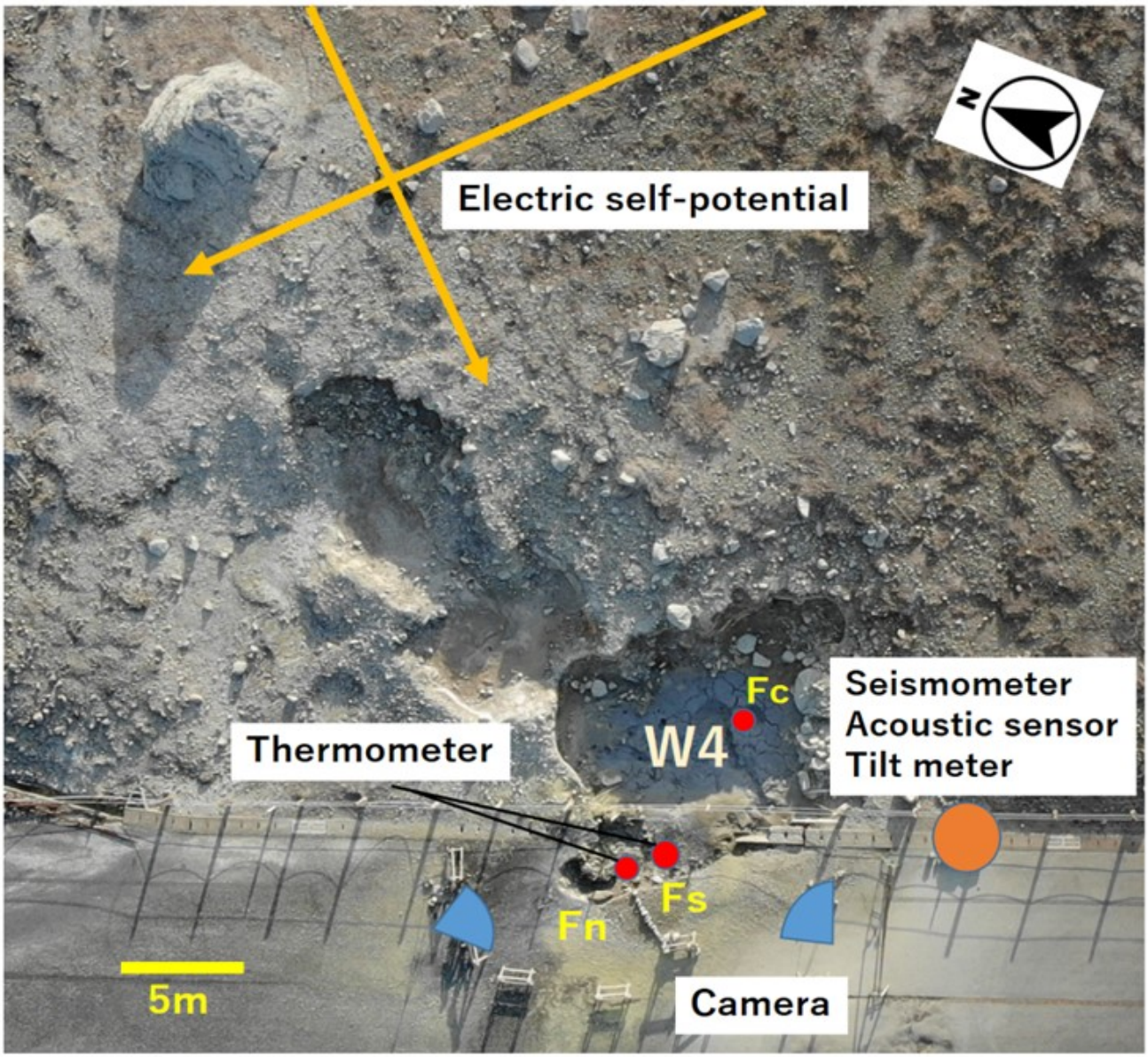

Fig. 1: Layout of instrument. This picture was taken of west crater W4 from the sky with a drone. The red circles in the figure indicate three vents (Fn, Fs and Fc).

