

Increase in the temperature of hot spring waters in Hakone observed in 1960s.

Kazuhiro Itadera^{1*}, Joji Kikugawa¹, Akio Yoshida¹

¹HSRI, Kanagawa Pref.

In the 1960s, a notable increase in the temperature of hot spring waters in the Hakone caldera was observed around the area of Gora and Sokokura. The event was memorable in that it was used by Oki and Hirano in their famous theory concerning the formation of hot springs in the Hakone caldera. According to Oki et al. (1968), Hirano et al. (1968) and Hirota et al. (1970), the temperature increase was observed for those hot spring wells classified as zone III. Hot spring waters of this zone, characterized by high temperature and high concentrations of NaCl, are considered to be formed by ground water mixing with high-temperature, high-pressure steams arising from the magmatic body thought to exist beneath the area around Soun Jigoku. Of the four types of hot springs in Hakone, the zone III type is thought to contain the highest count of magmatic volatile components (Oki and Hirano, 1970). Given this, the notable increase in the temperature of hot spring waters in 1960s was thought to reflect some sort of volcanic activity. The occurrence of swarm earthquakes in 1966 was also believed to be related to the activity. Machida et al. (2007) proposed a different explanation of the origin of the hot spring waters of zone III by bringing data together from the events of the 1960s with hydraulic head measurements from wells around the area. He argued the following: Trends in the distribution in the NW-SE direction of those wells with high concentrations of NaCl and classified as zone III hot springs by Oki and Hirano (1970) do not accord with the direction of ground water flows as estimated by head measurements. Machida et al. (2007) claimed that, given that the spatial distribution of the zone III wells does not represent ground water flows from Soun Jigoku, it would be most proper to understand steams with high concentrations of NaCl to reflect the location of the mouth of volcanic steams of deep magmatic origins running from W-NW to E-SE. Machida et al. (2007) buttresses his argument by pointing out that an eastward migration of the area where temperature increased, such as shown by Oki and Hirano (1970), was in fact not confirmed.

As described above, two different explanations have been presented concerning the sharp temperature-increase events in 1960s and two different hypotheses about the origin of hot spring waters in Hakone have been proposed based on these explanations. In this paper, we report the results of our detailed research, conducted with no preconceptions, using all the available data about the observation of hot spring water temperatures. The results of the study are as follows.

1. The increases in temperature was notable for zone IV hot spring waters in the Sokokura area, not for those of zone III.
2. Significant increases in temperature were observed at only two wells in the NW-SE area where many zone III hot springs are located. The two wells were not classified as zone III wells.
3. Further, it appears that the increase of temperature at the wells of Zone IV at Sokokura preceded the increase of temperature at the two wells located in the Zone III.
4. Most of the wells which showed a notable increase of temperature were located on the right bank of Jakotsu river where water levels are extremely shallow and many of the wells are naturally emergent.
5. Increase in temperature was not observed at the wells of zone III which had originally showed

very high temperatures exceeding 80 degrees Celsius.

Further consideration is necessary in order to determine the significance of the above findings concerning the temperature-increase of hot spring waters in the areas of Gora and Sokokura in 1960s and 1970s.

Keywords: Hakone, Hot spring water, Temperature increase