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Relationship between volcanic activity and chemical and isotopic compositions of thermal waters in Tokachidake, Japan

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Tokachidake volcano, one of the most active volcanoes in Japan, caused three magmatic eruptions (AD 1926, 1962 and 1988-89) in the 20th century, and the volcanic activities tend to increase recently. In this study, we investigate chemical and isotopic compositions of thermal waters in Tokachidake volcano and discuss the relationship to the volcanic activity.

Bengara hot spring (BHS), Hakuginso hot spring (HHS), Fukiage hot spring (FHS) and Okina hot spring (OHS) are located at the western flank of the volcano, about 3 km from the summit craters. Chemical compositions of BHS, FHS and OHS and those of HHS have been continually investigated since AD 1986 and 1992, respectively. The temperature of thermal waters of BHS, HHS and FHS ranges from 48 to 56 ^{o}C, whereas that of OHS is about 25 ^{o}C. These thermal waters are acidic with the pH ranging from 2.5 to 3.0.

The chemical compositions of these thermal waters show temporal changes. The Cl/SO_4 ratio of these thermal waters was about 0.2 in AD 1986. Since then the Cl/SO_4 ratio had abruptly increased, and the ratio of BHS and FHS was about 2.9 and 3.9, respectively, at the time of the AD 1988-89 eruption. The increase of the ratio had continued until AD 1992, whereas then the ratio had decreased to 0.6 until AD 2010. Temporal change of the chemical compositions of HHS shows nearly the same as that of BHS and FHS, and the ratio had decreased until AD 2010. Since AD 2010, however, temporal change of the ratio of these three thermal waters has changed to constant or weak increase. In addition, these thermal waters have shown obvious increase of the ratio since June 2012, and the ratio reached about 1.0. In contrast, temporal change of the chemical compositions of OHS is clearly distinct with that of other thermal waters, and the ratio have roughly decreased until the present. In all thermal waters, there is no remarkable temporal variation of SO_4^{2-} concentration, and hence we can consider that temporal change of the Cl/SO_4 ratio has been caused by change of Cl^{-} concentration.

In addition to the chemical compositions, the oxygen and hydrogen isotopic compositions of these thermal waters have been investigated since AD 2011. All samples collected before July 2012 show nearly the same isotopic compositions as meteoric waters, ranging from $d^{18}O$=-13.6 to -12.1 per mil. In contrast, thermal waters of BHS and HHS, which were collected after October 2012, show heavy oxygen isotopic composition compared with meteoric waters, ranging from $d^{18}O$=-10.9 to -9.8 per mil.

The increase of the Cl/SO_4 ratio of thermal waters and shift of the oxygen isotopic composition toward heavier value indicate that supply of volcanic gas into thermal waters has increased. Observations of chemical and isotopic compositions of thermal waters are important for evaluating the future volcanic activity of Tokachidake volcano.

Keywords: Tokachidake volcano, thermal water, stable isotope, chemical composition