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Remote temperature sensing on the fumarolic area in Aso Volcano using hydrogen isotopic compositions of plume H_2

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Molecular hydrogen (H_2) in a high-temperature volcanic fumarole ($>$ 400 degreeC) reach to the hydrogen isotope exchange equilibrium with coexisting fumarolic H_2O under the outlet temperature of the fumarole. In this study, we applied this hydrogen isotope exchange equilibrium of fumarolic H_2 as a tracer for the remote temperature sensing on the fumarolic area in the 1st crater of Mt. Naka-dake (Aso volcano) where direct measurement on fumaroles was not practical, by deducing the hydrogen isotopic composition (dD value) of fumarolic H_2 remotely from those in volcanic plume.

The reciprocal of H_2 concentration in the plume samples showed a good linear relationship with the dD values. The linear relationships suggested that both the concentrations and the dD values of H_2 in the plume samples can be explained by simple mixing between two end-members, both of which can be classified to a single category at least for the dD values of H_2. By extrapolating the linear relationship between 1/H_2 and dD to 1/H_2=0 to exclude the contribution of the tropospheric H_2 from the dD value of each sample, we estimated that the dD value of fumarolic H_2 to be -172+-16 per mil vs. VSMOW and the apparent equilibrium temperature (AET_D) to be 868+-97 degreeC. Although the estimated temperatures using the IR thermometers were much lower than the AET_D, we concluded that the AET_D represented the highest outlet temperature of the fumaroles in Aso volcano and that the dimensions of the fumaroles at surface smaller than the pixel of the IR thermometers was responsible for the temperatures lower than the AET_D. That is to say, temporal variation in the dimensions of fumaroles at surface, probably due to variation in the emission flux of fumarolic gases, was responsible for the temporal variation in the temperature determined by the IR thermometers, while the actual outlet temperature of the Aso fumaroles keeps the temperature almost equal to the equilibrium temperature of fumarolic gases.

Keywords: fumarolic gases, volcanic plume, molecular hydrogen, stable isotopes, isotope exchange equilibrium, remote temperature sensing