

Volcanic gas measurements using the virtual Multi-GAS method

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Introduction: In recent years, so-called “Multi-GAS” system that consists of several gas sensors has been developed to measure the chemical composition of volcanic gases in the field (Aiuppa et al., 2005; Shinohara, 2005). While such systems are usually produced as all-in-one devices, we considered that assemblage of inexpensive ready-mode portable gas sensors might also work as a comparable system. In this study, we assembled three portable gas concentration meters in a plastic basket that has a good aeration property, and attached it to a stretchable aluminum stick. We applied this instrumentation to the fumaroles of Mt. Tokachidake and Mt. Tarumae, Hokkaido, Japan.

Field operation: As the commercial gas sensors used in this study were gas alarm devises for safety management, the resolutions were not very high (0.1ppm for H₂S, 1ppm for SO₂, 1ppm for CO₂). In addition, the response time of the CO₂ sensor was approximately one minute, which was considerably slower than the H₂S, SO₂ sensors. For these reasons, we walked slowly in rather dense plumes, and took one-minute moving average on the time series of H₂S and SO₂ in order to match them to the CO₂ sensor with the longest time constant. Since the SO₂ sensor did not have a logging function, its LCD was photographed at every two seconds by a smartphone.

Results: We measured the plumes from Taisho-vent at Mt. Tokachidake on September 23, 2014. Due to the prevailing wind and topographic constraint, several lines of plumes typically run up eastward along the crater wall, to the rim . Therefore, we walked along the crater rim to obtain sufficiently dense gas concentrations. The peak values of each component were H₂S ~ 50ppm, SO₂ ~ 80ppm and CO₂ ~ 170ppm (above background). Molar ratios between compositions were estimated from the linear trends of the scatter plots as H₂S/SO₂ ~ 0.48, CO₂/H₂S ~ 5.9 and CO₂/SO₂ ~ 2.9. Comparing our results to the ones measured by Geological Survey of Japan, AIST in July, 2014 (Shinohara, personal comm.) through direct sampling, the difference was less than 15%, suggesting our method had an enough accuracy.

We further performed the same measurements at A and E-vents of Mt. Tarumae on October 22, 2014. The peak values of each component were H₂S ~ 12ppm, SO₂ ~ 3ppm and CO₂ ~ 70ppm (above background). Unlike the result from Mt. Tokachidake, SO₂ concentration of Mt. Tarumae was close to the detection limit. Therefore, the estimations of H₂S/SO₂ and CO₂/SO₂ were relatively unreliable. Molar ratios were estimated as H₂S/SO₂ ~ 2.4, CO₂/H₂S ~ 6.1 and CO₂/SO₂ ~ 17 at A-vent, and H₂S/SO₂ ~ 8.9, CO₂/H₂S ~ 13 and CO₂/SO₂ ~ 100 at E-vent.

Emission rate: We tried to estimate not only the component ratios but also the emission rate for Tokachidake. We profiled the gas concentrations along the crater rim of Taisho-vent at three heights (2.7, 3.8 and 5.0m) by sliding the stretchable stick, and obtained a concentration map on the plume section. As described above, most of the gas passes just on the rim below 5.0m and thus the concentration above 5.0m was likely to be small. Therefore, the contribution of the upper flow was taken into consideration just by extrapolation from the lower part. The flow speed was estimated from the video image taken from a slightly remote site. Then, the SO₂ emission rate was estimated as 7-9t/d.

Conclusions: We verified that our system worked properly in measuring gas component ratios at least when applied to sufficiently dense plumes. We also demonstrated that it is possible to estimate the emission rate by contouring for the plumes flowing near the ground surface. We consider that the instrumentation is so light-weight that it can be attached to an unmanned aircraft such as a multicopter drone. It will be possible in the near future to widen the opportunities for gas measurements without exposing an observer to potential dangers in the field.

Keywords: volcanic gas, Mt.Tokachidake, Mt.Tarumae