Mass Spectrometer-based Instrument for Volcanic Gas Monitoring

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One very harsh environment for terrestrial applications of mass spectrometry is active volcanoes, where continuous gas monitoring has both practical, hazards mitigation and basic research goals in observing and understanding the systematics of volcanic and hydrothermal systems. We developed and field tested an instrument that is capable of acquiring multiple-species gas chemistry data at active, low-to-moderate temperature fumaroles. The current prototype consists of a quadrupole mass spectrometer, a series of pumps, valves and control/data logging electronics housed in a corrosion-resistant container. We tested the instrument at the summit of Kilauea volcano in March, 2006, collecting time-series data from a 96°C fumarole (Sulphur Banks) at 15 minute intervals for nearly 3 days. Two temperature probes were utilized, a thermocouple placed in the gas stream and a thermistor which recorded ambient air temperatures inside the instrument housing. The fumarole gas composition, as indicated by sharp drops in the instrument response for N2, O2, Ar, and water vapor, and increases in CO2 and SO2 was reached at about 6.5 hours elapsed time.

The two most obvious gas/temperature trends in this brief time-series are: (1) sharp discontinuities caused by two of the standard "Giggenbach" bottle sampling interludes (despite some care given not to vent the gas line to atmosphere); and (2) two distinct types of thermal events. The two sampling interruptions caused decreases in temperature, and caused the responses of CO2, N2, O2, Ar and water vapor and the ratio of CO2/He to rise sharply. This appears consistent with contamination by cooler ambient air enriched in CO2 relative to normal air (solfatara air). The two types of thermal events are similar in that both generally show enrichments of SO2 and He, and decreases in CO2/He, whereas the last, much hotter event displays increases in CO2, N2, O2, Ar, and water vapor, in contrast to decreases in these gases during the two former events. The last thermal event correlates with a brief dry period on 17 March, after a previous week of almost continuous rainfall. An interesting increase in the HD/H2 ratio suggests either HD-enriched H2 gas or water vapor was introduced during the last thermal event, which is consistent with a fumarole influenced by evaporated, boiling water and atmospheric gases at depth.

During our tests we discovered several problematic issues that need to be overcome if the instrument is to be deployed for extended periods of time (months to years) in harsh and remote locations of active volcanoes. One of the main obstacles is the large amount of water vapor in fumaroles and the need for keeping that water out of the mass spectrometer. We have successfully achieved this using a series of traps and a condenser that still allow the other species to enter the instrument. Related problems are loss of some of the reactive gases within the instrument and/or traps and the precipitation of elemental sulfur in the pre-mass spec inlet system. Another issue that we are currently addressing is the relatively high power consumption of the instrument and condenser.