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Gas geothermometry for typical and atypical hydrothermal gases: A case study of Mount Mageik and Trident Volcanoes, Alaska

Lopez Taryn (1), Franco Tassi (2,3), Francesco Capecchiacci (2,3), Giovanni Chiodini (4), Jens Fiebig (5), Andrea Rizzo (6), and Stefano Caliro (7)

(1) Alaska Volcano Observatory, Geophysical Institute, University of Alaska Fairbanks, 903 Koyukuk Drive, Fairbanks, AK 99775, USA, (2) Department of Earth Sciences, University of Florence, Via La Pira, 4, 50121, Florence, Italy, (3) Institute of Geosciences and Earth Resources of the National Research Council (CNR-IGG), Via La Pira, 4, 50121, Florence, Italy, (4) Istituto Nazionale di Geofisica e Vulcanologia, Bologna, Italia, (5) Institut für Geowissenschaften, Goethe-Universität, Altenhöferallee 1, 60438 Frankfurt am Main, Germany, (6) Istituto Nazionale di Geofisica e Vulcanologia,Via U. La Malfa 153, 90146, Palermo, Italia, (7) Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Vesuviano, Via Diocleziano, Napoli, Italia

The chemical and isotopic composition of volcanic gases can be used to detect subsurface magma, qualitatively constrain magma degassing depth, evaluate temperature and pressure conditions of hydrothermal reservoirs, and constrain volatile sources, all of which are important for volcano monitoring, eruption forecasting and hazard mitigation. Two persistently degassing and seismically active volcanoes from the Katmai Volcanic Complex, Alaska, were targeted during this study to characterize subvolcanic conditions. Fumarole and steam condensate samples were collected for chemical and isotopic analysis from Mount Mageik and Trident Volcanoes in July 2013. These volcanoes are located within 10 km of each other, both show evidence for active hydrothermal systems, and both have boiling point temperature fumaroles, yet emit notably different gas compositions. Mount Mageik's gases are composed primarily of H20, CO_2, H2S, and N2, with minor CH4, CO and H2 and negligible HCl amounts, reflecting a typical "hydrothermal" gas composition. Although, Trident's gases are somewhat similar in composition to those of Mount Mageik, they show several unusual features for hydrothermal fluids, most notably extremely high concentrations of reduced gas species. Specifically, the H2/H_2O values are $\approx$1 log-unit lower (i.e. more reducing) than those produced by the rock redox buffers commonly dominating in a hydrothermal environment. These anomalous ratios are accompanied by relatively high concentrations high-temperature (CO, and H2S), and low temperature (CH4) gases, suggesting a strong chemical disequilibrium and/or chemical-physical conditions far from those typically acting on hydrothermal fluids. Additionally, when δ13C ratios of methane, ethane and propane are considered, a deviation from the expected "hydrothermal" carbon number trend is observed for Trident volcano, suggesting an "abiogenic reversal". Gas geothermometry in the H_2O-CO_2-H2-CO-CH4 system provides estimated temperatures of 220-260°C for the Mount Mageik gases, whereas the Trident's gas composition corresponds with unreliable temperatures. Considering the presence of what appears to be consolidated organic material (e.g. coal?) in the substrate beneath Trident, we test a new geothermometer based on redox reactions between CO_2 and graphite, in an effort to constrain hydrothermal reservoir temperatures at Trident volcano. Preliminary results and interpretations are presented, and suggestions for improvement are welcome.