Quantifying carbon dioxide flux from dormant volcanoes with low-temperature fumarolic activity: demonstration from measurements at la soufriere, guadeloupe, and campi flegrei, italy

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Quantifying the flux of magma derived CO2 dissipated by fumarolic fields at dormant volcanoes is fundamental to assess their current state of hydrothermal activity and, therefore, the likelihood of a future phreatic/magmatic eruption. There is, in fact, documented evidence that gas fluxes, and CO2 flux in particular, can increase substantially during volcanic unrests and prior to eruption, due to either degassing of new ascending magma or changes in the hydrothermal system physical regime. Quantifying CO2 emissions is relatively straightforward at open-conduit volcanoes with high-temperature gas venting, which release high enough quantities of SO2 remotely measurable with UV spectroscopy and where CO2 flux can then be obtained by scaling to fumarole CO2/SO2 ratios. Less actively degassing systems (T less than 300 C), in contrast, release sulphur predominantly as H2S, that is far more difficult to detect optically than SO2, and other procedures are therefore necessary. The main point is that many dormant volcanic systems worldwide fall in this second category.

Here we present the first CO2 budget estimates for two dormant volcanoes displaying intense fumarolic activities: La Soufriere of Guadeloupe (Lesser Antilles arc) and Campi Flegrei (Naples, Italy). Both volcanic systems have produced voluminous pyroclastic eruptions in the past and have shown signs of unrest during the last decades (phreatic eruptions at La Soufriere; occasional seismic swarms, extensive degassing and ground uplift at Campi Flegrei). While the CO2 output by diffuse soil degassing is relatively well known at both systems, no accurate CO2 budget for their fumarolic exhalations has been obtained so far. For quantifying this budget we used a portable MultiGAS sensor system that allowed us to determine the horizontal/vertical concentration profiles of CO2 (plus H2O, SO2, H2S and H2) along cross-sections of the gas plumes generated by the fumarolic activity, perpendicular to the plume transport direction. Gas sampling data at 0.5 Hz and simultaneous GPS positioning provided us with the required temporal/spatial resolution to map the chemical heterogeneity of plumes. By integrating over the entire plume section, and scaling to measured plume transport speed (for thermal/UV/video imaging), the CO2 fluxes were calculated. The validity of this methodology was also tested at Campi Flegrei by comparison with independent CO2 flux estimates which we obtained with a Tuneable IR Laser (good match between the two independent flux estimates). Our results show that fumarolic CO2 emissions are significant at both volcanoes (e.g. 1000 t/day at Campi Flegrei, about as much as from diffuse soil degassing, and 30 to 60 t/day at La Soufriere). We propose that the experimental procedure described above can be applied to many other comparable volcanic targets worldwide in order to improve our knowledge of the budget for global volcanic CO2 emissions.