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Field isotope-ratio analysis of carbon dioxide in volcanic gases by means of high-precision diode-laser spectrometry

L. Gianfrani, A. Castrillo, G. Casa, D. Tedesco

Department of Environmental Sciences, Second University of Naples, Caserta, Italy
(livio.gianfrani@unina2.it / Fax +39 0823 274605)

Isotope analysis represents an extremely important tool in a variety of research fields, including global change biology, atmospheric chemistry, and bio-medicine. In geochemistry, variations of isotopic parameters in volcanic gases are being studied as indicators of impending eruptions, as they enable researchers to understand source-region changes, which are fundamental to monitor and forecast volcanic activity. Nowadays, geochemical monitoring of volcanoes requires periodic sampling of gases followed by laboratory analysis, isotope ratios being determined by means of conventional mass spectrometry. Recently, optical methods have shown great potential in remote or field analysis of volcanic gas composition. On the other hand, infrared laser spectroscopy can provide accurate determinations of stable isotope ratios, exploiting the high sensitivity, resolution and precision with which it is possible to observe an absorption line profile. Here we show that carbon isotope ratio analysis can be performed in the field using a laser-based system, designed and implemented to work inside the harsh environment of a volcanic site. For the first time, accurate determinations of the $^{13}CO_2/^{12}CO_2$ ratio have been carried out, in a quasi-continuous regime, inside the Solfatara crater, a small volcano near Naples. Field data were in excellent agreement with laboratory determinations, carried out by means of isotope ratio mass spectrometry. Regular and frequent observations of the carbon isotopes in volcanic gases, which become possible with our methodology, would enhance the capabilities of isotope-geochemistry to closely monitor changes in volcanic activities.