

## TOOLS OF THE TRADE

# Measuring forgotten volcanic CO<sub>2</sub>

Carbon dioxide (CO<sub>2</sub>), one of the most abundant gases emitted by active volcanoes, is released primarily through the volcanic central vent and fissures, but large volumes of CO<sub>2</sub> can also be passively emitted through volcanic soils. As the presence of atmospheric CO<sub>2</sub> prevents the use of remote techniques, these so-called diffuse emissions remain unmeasured at many volcanoes, and labour-intensive field work is required to constrain them. Consequently, the global volcanic CO<sub>2</sub> emissions of ~320 million tonnes per year are likely underestimated.

Diffuse CO<sub>2</sub> emissions can be determined, but to do this they must be measured directly on or near the soil surface. The most common method is to use a portable CO<sub>2</sub> flux meter, which consists of an analyser with an infrared sensor that measures the change in CO<sub>2</sub> concentration in a chamber placed over the soil surface. Individual flux measurements are straightforward: place the chamber over the chosen spot, hold it stationary for up to 2 minutes while it collects data, and record the measurement. Although the measurement is simple, a flux survey can involve collecting more than 1,000 data points from one volcanic area, which takes weeks. From this, the amount of diffuse CO<sub>2</sub> emitted over an area in tonnes per day can be estimated.

Studies estimating diffuse emissions using CO<sub>2</sub> flux meters reveal that surprisingly high volumes of CO<sub>2</sub> can be measured from the soils surrounding volcanic vents. For example, diffuse CO<sub>2</sub> emissions could account for around half of the total emissions at the Mud Volcano site in Yellowstone, and a quiescent volcano in Italy exhibited diffuse soil fluxes similar to those from active volcanic craters. CO<sub>2</sub> flux



Rahilly measuring CO<sub>2</sub> flux from volcanic soils. Photo courtesy of K. Rahilly, University of New Mexico.

surveys have provided better constraints on global volcanic CO<sub>2</sub> emissions, which alongside thermal, isotopic and geophysical information can give deeper insight into volcanic systems. However, CO<sub>2</sub> flux surveys provide only a snapshot of diffuse emissions at one time, preventing longer-term information on temporal variability. Newer continuous

soil CO<sub>2</sub> flux sampling systems offer lower spatial resolution, but show promise for volcanic activity monitoring.

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