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Natural gas emissions affecting a densely populated area at Cava dei Selci (Latium, Italy): Insights into the environmental impact from multi-instrumental geochemical measurements

Franco Tassi (1,2), Jacopo Cabassi (1,2), Stefania Venturi (1,2), Ilaria Minardi (3), Simone Neri (3), Chiara Caponi (1), Andrea Ricci (4), Francesco Capecchiacci (1,2), Orlando Vaselli (1,2), and Giorgio Virgili (4)

(1) University of Florence, Earth Science Department, Earth Sciences, Florence, Italy (franco.tassi@unifi.it), (2) CNR – Institute of Geosciences and Georesources, National Research Council (IGG-CNR), Via G. La Pira 4, 50121 Florence (Italy), (3) WEST Systems Ltd., Via Don Mazzolari 25, 56025 Pontedera (Italy), (4) Department of Biological, Geological and Environmental Sciences, University of Bologna, Porta S. Donato 1, 40136 Bologna (Italy)

The Colli Albani volcanic complex (Lazio, Italy) shows areas (e.g. Tivoli, Cava dei Selci, Tor Caldara, Solforata) characterized by an anomalously high soil gas emission originated from a regional CO_2-saturated aquifer hosted within Mesozoic carbonate rock sequences. These natural gas manifestations, dominated by CO_2 and showing significant concentrations of CH4, H2S, and Rn, represent a serious hazard for local inhabitants, especially where residential zones are in a close proximity to the exhalations, such as at Cava dei Selci. Notwithstanding the insistent recommendations based on out- and in-door measurements of toxic gases clearly highlighting the strong hazard posed by this situation, the political authorities have not found any exhaustive solution. After the installation of a CO_2 measurement station that was prematurely dismissed, the main emission zone, consisting of a depression corresponding to an old quarry discharging up to 25 tons/day and 84 kg/day of CO_2 and H2S, respectively, was fenced and then abandoned.
In April 2016, a research team from the University of Florence and WEST Systems Ltd. (Italy) carried out a fieldtrip in this area for investigating the air quality. The measurement strategy was thought to provide a snapshot of the concentrations in air of the main deep-originated gas compounds along a pattern passing through the urban settlement mostly exposed to the lethal gases. A crawler mobile and remote-controlled vehicle was able to cover in 2 hours a grid within the inhabited center of Cava dei Selci, bringing high-sensitivity and synchronized instruments set at high-frequency acquisition, including: 1) a Tunable Diode Laser Absorption Spectroscopy (TDLAS) combined with a Herriot cell (CH4); 2) an infrared spectrometer with OA-ICOS technology (CO); 3) a Licor Li-820 infrared spectrometer (CO_2); 4) a Thermo Scientific Model 450i gas analyzer (H2S and SO_2); 5) a Lumex RA-915M analyzer (Hg0); 6) a Garmin GPS and a Davis Vantage Vue Weather station (position and the main meteorological parameters, respectively).
The dataset, consisting of up to 7,000 measurement spots, showed that concentrations of CO_2, H2S, CH4, and CO in the study area were, at a first approximation, consistent, whereas those of SO_2 and Hg0, not present in significant amounts in the contaminating source, were randomly distributed. A more detailed comparison of the gas concentration peaks revealed that in most cases the spatial distribution of CH4 surprisingly showed significant differences with respect to those of CO_2 and CO. This suggests that even at a relatively short distance from the gas source CH4 in air is affected by oxidation processes, masking the effects of the physical parameters (e.g. wind direction) that typically control the spatial distribution of air pollutants. On the contrary, H2S, which is supposed to rapidly turn to SO_2 by photochemical processes once emitted into the air, was in strong relation with the oxygenated carbon-bearing gases.
Although these promising results need to be integrated with those from further surveys, the multi-instrumental approach that was adopted seems to be particularly efficient for investigations aimed to assess the quality of air in contaminated areas