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A permanent volcanic hazard hiding in diffuse degassing areas

Fátima Viveiros (1), Catarina Silva (1,2), Teresa Ferreira (1), Joana Pacheco (1,2), and João Luís Gaspar (1)

(1) IVAR - Instituto de Investigação em Vulcanologia e Avaliação de Riscos, Universidade dos Açores, Ponta Delgada, Portugal (maria.fb.viveiros@azores.gov.pt), (2) CIVISA - Centro de Informação e Vigilância Sismovulcânica dos Açores, Universidade dos Açores, Ponta Delgada, Portugal

Carbon dioxide (CO_2) is one of the most abundant volcanic gases and it is released not only during eruptive events, but also during periods of quiescence through fumaroles, springs and soil diffuse degassing areas. In this last case, CO_2 is permanently and silently released from the soils and high CO_2 concentrations can be measured if the gas accumulates in depressed and non-ventilated areas (such as caves, pits), or even if it enters in buildings. From a public health perspective CO_2 is considered an inert asphyxiant gas and may be lethal when present in concentrations higher than 10 vol.%. In the last 30 years several diffuse degassing areas have been identified in different volcanic systems and lethal incidents due to high CO_2 concentrations were reported in volcanic environments of Italy (Alban Hills), New Zealand (Rotorua), Cameroon (Lake Nyos and Lake Cameroon), USA (Mammoth Mountain) and Portugal (Azores archipelago). In the Azores volcanic archipelago several villages are located in diffuse degassing areas, where lethal indoor CO_2 concentrations (> 20 vol.%) were measured. Recent studies showed that the rate of CO_2 emission may change not only during seismo-volcanic unrest, but also due to changes in the meteorological conditions (e.g. barometric pressure, rainfall, wind speed).

Few works are available in the literature with permanent monitoring of indoor CO_2 in diffuse degassing environments and the monitoring tests are usually applied during a short period of time. This study shows the results of four years (2012-2016) of permanent CO_2 monitoring in 12 buildings placed at Caldeiras da Ribeira Grande, an area located in the north flank of Fogo Volcano (São Miguel Island, Azores archipelago), where thermal anomalies and CO_2 emissions were detected. CO_2 fluxes as high as 20000 g m-2 d-1 are released from the soils and temperature in some sites reaches 100ºC.

Spike-like and long term variations are observed in the time series recorded by a total of 52 infrared CO_2 detectors installed. Results highlight that CO_2 can reach hazardous concentrations (> 15 vol.%) due to meteorological changes and show the occurrence of seasonal variations. Different indoor CO_2 patterns are displayed depending on the location of the buildings over thermal anomalous zone. Due to its density at standard temperature and pressure, CO_2 tends to accumulate in the underground and/or in the ground floor of the buildings, however in the present study higher CO_2 concentrations were also measured in the upper floors of some buildings, fact that is correlated with the presence of thermal anomaly.

Results obtained based on this robust and continuous monitoring system show once again that indoor CO_2 can reach frequently lethal concentrations even in periods of quiescence and that inhabitants of these buildings are exposed to a permanent and quiet hazard, which is detected only through the use of specific instruments. The existence of thermal anomaly associated with the CO_2 emission is also responsible for different patterns when compared with the “cold” CO_2 degassing areas.