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Anomalous diffuse H_2 degassing prior to the recent magmatic intrusion at Cumbre Vieja volcano, La Palma, Canary Islands

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Hydrogen (H_2) is one of the most abundant trace species in volcano-hydrothermal systems and is a key participant in many redox reactions occurring in the hydrothermal reservoir gas (Chiodini and Marini 1998). Although H_2 can be produced in soils by N_2-fixing and fertilizing bacteria, soils are considered nowadays as sinks of molecular hydrogen (Smith-Downey et al. 2006). Because of its chemical and physical characteristics, H_2 generated within the crust moves rapidly and escapes to the atmosphere. These characteristics make H_2 one of the best geochemical indicators of magmatic and geothermal activity at depth. Cumbre Vieja volcano (La Palma, Canary Islands) is the most active basaltic volcano in the Canaries with seven historical eruptions being Teneguía eruption (1971) the most recent one. Cumbre Vieja volcano is characterized by a main north–south rift zone 20 km long, up to 1950 m in elevation and covering an area of 220 $km^2$with vents located at the northwest and northeast. Cumbre Vieja does not show any visible degassing (fumaroles, etc.). For that reason, the geochemical volcano monitoring program at Cumbre Vieja volcano has been focused on soil degassing surveys. On October 7^{th} (2017) a remarkable seismic swarm interrupted a seismic silence of 46 years in Cumbre Vieja volcano: more than 75 earthquakes were located beneath Cumbre Vieja volcano at depths ranging between 15 and 28 km with a maximum magnitude of 2.7. On October 13rd a second seismic swarm, lasting about 14 hours, was registered with more than 47 earthquakes at depths ranging between 14 and 25 km and with a maximum magnitude of 2.1. Here we show the results of soil H_2 emission surveys that have been carried out regularly since 2001. Soil gas samples were collected in about 600 sampling sites selected to obtain a homogeneous distribution at about 40 cm depth using a metallic probe and 60 cc hypodermic syringes and stored in 10 cc glass vials. H_2 content was analysed later by a VARIAN CP4900 micro-GC. A simple diffusive emission mechanism was applied to compute the emission rate of H_2 at each survey. H_2 emission values were used to construct spatial distribution maps by using sequential Gaussian simulation (sGs) algorithm, allowing the estimation of the emission rate from the volcano. In the period 2001-2003, the average H_2 emission rate was $\sim$2.5 kg·d^{-1}. It increased significantly during the 2013-2017 period ($\sim$16.6 kg·d^{-1}), reaching the maximum value of the series (36 kg·d^{-1}) in June 2017, 4 month before the seismic swarms. H_2 emission surveys have demonstrated to be sensitive and excellent precursors of magmatic processes occurring at depth in Cumbre Vieja. Periodic H_2 emission surveys provide valuable information to improve and optimize the detection of early warning signals of future volcanic unrest at Cumbre Vieja volcano.

References:

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