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Soil gas CO_2 concentration, isotopic ratio and efflux measurements for geothermal exploration at Tenerife, Canary Islands

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The Canary Islands, owing to their recent volcanism, are the only Spanish territory with potential high enthalpy geothermal resources. Tenerife (2058 km2, 3718 masl) is the largest of the seven islands of the Canarian archipelago located off the west coast of North Africa and shows evident geothermal surface manifestations (Teide volcano fumaroles, the only visible discharge of geothermal fluids existing nowadays in the Canary Islands). Between 2011 and 2014, preliminary geochemistry and magnetotellurics surveys were carried out in the southern volcanic rift zone of Tenerife for geothermal exploration purposes. After the observed geochemical anomalies at the soil surface, the prominent low-resistivity structure interpreted as a clay alteration cap, and the positive correlation between thickness of clay alteration cap and helium emission and other positive results, it was decided to perform a detail diffuse CO_2 emission survey during July-August, 2018 at northern part of the study area where some geochemical and geophysical anomalies were observed. During this survey, 362 sampling sites, with an average distance between sites of $\approx$ 40 m, were selected along 0.7 km2 area. Soil gases were sampled at $\approx$ 40 cm depth using a metallic probe with a 60 cc hypodermic syringes and stored in 10 cc glass vials for later laboratory analysis. Soil CO_2 concentrations measured ranged from typical atmospheric values ($\approx$ 400 ppm) up to 15200 ppm. The mean value measured for CO_2 concentration was 2400 ppm. The CO_2 isotopic composition, expressed as δ13C-CO_2 showed the contribution of three different end-members: biogenic, atmospheric and deep-seated CO_2, defined by isotopic compositions of -24, -8 and -3 ‰ vs. VPDB, and CO_2 concentration of 100%, 0.04% and 100% respectively. The results indicate that most of the sampling sites exhibited CO_2 composed by different mixtures between atmospheric and biogenic CO_2 with slight inputs of deep-seated CO_2, with a mean value of -17.1‰ being the maximum and the minimum -3.6‰ and -24.1‰ respectively. The accumulation chamber method (Parkinson, 1981) was used to perform soil CO_2 efflux measurements at each sampling site by means of a portable non dispersive CO_2 sensor, model LICOR-Li-820. Relatively low CO_2 efflux values were measured ranging from non detected up to 55.4 g m-2•d-1, with an average value of 4.2 g m-2•d-1. The highest CO_2 efflux values were measured as multiple isolated anomalies, where it was not observed significant trends in the diffuse CO_2 efflux anomalies distribution. To estimate the total diffuse CO_2 output released from the study area, the average of 100 sequential Gaussian simulations was considered, giving a value of 2.37 $\pm$ 0.07 t d-1, which represent a normalized emission rate of 3.4 t km-2•d-1vs. 1.9 t km-2•d-1 for the previous study area of 2014. The results showed here can help to identify the possible existence of permeable portions of deep-seated actively degassing geothermal reservoirs, particularly where the interpretation and application of geophysical data is difficult.