Soil gas CO2 concentration, isotopic ratio and efflux measurements for geothermal exploration at Cumbre Vieja volcano, La Palma, Canary Islands

Alba Martín Lorenzo1,2, Banner Cole3, Elizabeth Bullock4, Sahilla Abassi5, Lía Pitti-Pimienta1, Ana Meire1, Cecilia Amonte1, Gladys V. Melián1,2,6, Pedro A. Hernández1,2,6, and Nemesio M. Pérez1,2,6

1Instituto Volcanológico de Canarias (INVOLCAN), 38240 La Laguna, Tenerife, Canary Islands, Spain
2Instituto Tecnológico y de Energías Renovables (ITER), 38600 Granadilla de Abona, Tenerife, Canary Islands, Spain
3Geology Department, St. Lawrence University, Canton, New York
4Department of Physics, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago
5Civil Engineering Department, University of Toronto, Ontario, MSS 1A4, Canada
6Agencia Insular de la Energía de Tenerife (AIET), 38600 Granadilla de Abona, Tenerife, Canary Islands, Spain

The exploration of geothermal resources on the island of La Palma, Canary Islands, was first conducted by the Spanish Geological Survey (IGME) from 1982 to 1984. These studies were focused exclusively on the southern part, where the last historical eruption, Teneguía, took place in 1971. This area still shows some geothermal features such as relatively high ground water temperatures (about 40°C) and soil CO2 efflux values. Recent studies carried out at Cumbre Vieja volcano, the southern part of the island, on diffuse degassing, 3D gravimetry and Audio-MT probes point to promising results, although more studies are needed. We continue applying a multidisciplinary approach to obtain additional information about the geothermal system underlying at Palma island using novel techniques as well as tools which are appropriate to evaluate this system. For this reason, during summer 2019 a soil diffuse degassing research started at Cumbre Vieja volcano (220 km²) for geothermal exploration purposes. In this first phase of the diffuse degassing study about 1,200 sampling sites, with an average distance between sites of approximately 250 m were selected after taking into consideration the volcano-structural features and accessibility. In each sampling site in-situ soil CO2 efflux measurements were performed, and soil gas samples were collected at 40 cm depth for chemical and isotopic analysis. Spatial distribution of CO2 efflux, statistical-graphical analysis of CO2 efflux, and δ13C-CO2 isotopic data to calculate and map the volcano-hydrothermal contribution of CO2 were combined and used for geothermal exploration. The statistical-graphic analysis of the diffuse CO2 efflux values confirms the existence of different geochemical populations showing two log-normal geochemical populations, a fact that suggests the addition of deep-seated CO2. Relatively low CO2 efflux values were measured ranging from non-detected up to 72.8 g m⁻² d⁻¹, with an average value of 4.6 g m⁻² d⁻¹. The highest CO2 efflux values were measured at the north end of Cumbre Vieja, around the surface contact with Cumbre Nueva ridge. The CO2 isotopic composition, expressed as δ13C- CO2 showed the contribution of three different end-members: biogenic, atmospheric and deep-seated
CO₂. The results indicate that most of the sampling sites exhibited CO₂ composed by different mixtures between atmospheric and biogenic CO₂ with slight inputs of deep-seated CO₂, with a mean value of -15.3‰, being the maximum and the minimum -2.8‰ and -25.4‰ respectively. The results showed here can help to identify the existence of zones where deep-seated actively degassing from geothermal reservoirs occurs, particularly where the interpretation and application of geophysical data might be difficult.