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Diffuse degassing at the oceanic volcanic island of Madeira, Portugal

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Madeira is an intraplate volcanic island, located in the eastern North Atlantic Ocean, 500 km north of the Canaries. It is a topographically very heterogeneous island, with an emerged area of 737 km2. Madeira lies in a region of low seismicity rate (<40 events/yr) with events of low to moderate magnitudes (ML <4.0). Madeira figures in the list of worldwide hotspots since favored the existence of a mantle plume to explain hotspot volcanism in the region (Matos et al., 2015). Although no historical eruptions are documented, last subaerial eruption took place about 6,000 years ago. With the aim of providing a multidisciplinary volcano monitoring program for Madeira in the framework of the project, VOLRISKMAC (MAC/3.5b/124), a soil gas degassing survey was carried out carried out first time in May 2018, covering an area of 257 km2 located at the central sector of the island with a total of 472 sampling observation sites. The accumulation chamber method 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. Soil temperature at 15 and 30 cm depth was also measured in situ, whereas soil gases at each sampling point were collected by means of a stainless steel probe inserted 40 cm depth in the soil for further chemical and isotopic analysis in the laboratory. In order to investigate the spatial distribution of each geochemical parameter as well as to estimate the diffuse emission rates for CO_2, He, and H2, maps were constructed following sequential Gaussian simulation. Diffuse CO_2 emission values ranged between non detectable values to 104 g•m-2•d-1, with an average value of 9.4 g•m-2•d-1. Highest soil CO_2 efflux values were measured at the SW and NE sectors of the studied area. Estimated diffuse CO_2 emission rate for the studied area was 2,292 $\pm$ 8 t•d-1. The CO_2 isotopic composition (mean value -21.7‰ indicated that most of the sampling sites exhibited CO_2 composed by different mixing degrees between atmospheric and biogenic CO_2 with slight inputs of deep-seated CO_2. Regarding to He and H2, and assuming a pure diffusive mechanism, diffuse emission rates were estimated on 25 $\pm$ 1 kg•d-1 and 57 $\pm$ 2 kg•d-1, respectively. Most of the study area showed low He diffusive flux values, although an anomalous zone located to the east of the study area is clearly differentiated with measured values higher than 400 microg m-2•d-1. This area coincides with an anomaly of low S wave seismic velocity with an approximately circular shape, obtained through a seismic tomography study to investigate the upper cortical structure of the island of Madeira (Matos et al., 2015). On the other hand, spatial distribution of H2 emission values did not show a clear connection with main volcano-structures of the island. This work demonstrates the importance of performing diffuse emission studies as a promising volcano monitoring technique that might help to detect early warning signals of volcanic unrest in oceanic volcanic islands.

Matos C., et al 2015. J. Volcanol. Geoterm. Res. DOI: org/10.1016/j.jvolgeores.2015.03.017.