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Permanent carbon dioxide degassing at the Azores archipelago – footprints to understand deep processes

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Nowadays volcanic manifestations in the Azores archipelago are represented by several permanent gas emissions that include hydrothermal fumaroles, thermal and cold CO_2-rich springs, as well as diffuse degassing areas. Visible manifestations of volcanism are found out in most of the islands and their isotopic imprints give clues both to understand the origin of the fluids and the geodynamic setting of the archipelago.
The most vigorous fumarolic fields are associated to well-developed hydrothermal systems formed on the main quiescent central volcanoes of São Miguel, Terceira, Graciosa and Pico islands. A steam area associated to the last eruption that occurred at Faial Island is observed on Capelinhos Volcano. Despite these visible gas emissions, diffuse degassing areas have also been mapped in most of the islands and show a good correlation with the main extensional WNW-ESE, NW-SE and NNW-SSE tectonic structures identified at São Miguel, Terceira, Graciosa, Pico, Faial and São Jorge islands.
Fumaroles show a typical hydrothermal composition with water vapour (H_2O) as the most abundant volatile, followed by carbon dioxide (CO_2). The helium isotopic ratio (3He/4He) of the fumaroles from Graciosa and Terceira islands is different from that of São Miguel Island emissions that show ratios well below the Mid-Ocean Ridge Basalts, suggesting the addition of radiogenic 4He by mantle contamination with material with crustal origin. In what concerns the carbon isotopic compositions (13δ CCO_2), values are poorly variable all across the archipelago and vary between -4.66 and -3.10‰ PDB, respectively at Terceira and Pico fumaroles.
Important diffuse degassing structures (DDS) are found out associated to the main faults bounding graben structures that dominate the tectonics of São Miguel, Terceira and Faial islands, and constitute preferential paths for the gas ascent. The carbon isotopic composition of these anomalous CO_2 areas is similar to the main fumarolic fields and argues to a mantle-derived origin for the gases released in these permanent gas emissions sites. In fact, and even if some of the graben structures are not associated with active volcanoes, the CO_2 degassing still constitutes a permanent hazard in the archipelago as some buildings are built in anomalous CO_2 areas.