

Diffusive Helium Emissions as a Precursory Sign of Volcanic Unrest at El Hierro Island, Canary Islands, Spain

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Since July 16, 2011, an anomalous seismicity at El Hierro island, the youngest and smallest of the Canary Islands, was recorded by IGN seismic network. After the occurrence of more than 10,000 seismic events, a submarine eruption took place 2 km off the southern coast of El Hierro Island on October 12, 2011. Frequent episodes of turbulent gas emission and foaming, and the appearance of steamy lava fragments were observed on the sea surface. As part of the volcanic surveillance of the island, the Instituto Volcanológico de Canarias (INVOLCAN) geochemical monitoring program is carrying out diffuse helium surveys on the surface environment of El Hierro (soil atmosphere). This noble gas has been investigated because it has been considered an almost ideal geochemical indicator because it is chemically inert, physically stable, nonbiogenic, sparingly soluble in water under ambient conditions and almost non-adsorbable. The helium concentration gradients with respect to its value on air measured at 600 sampling sites allow us to estimate a pure diffusive emission rate of helium throughout the island. Since the beginning of the volcano-seismic unrest, 19 helium emission surveys have been carried out. The helium emission rate has shown an excellent agreement with the evolution of the volcanic crisis of the island, reaching 30 kg/d on October 6, several days before the occurrence of the submarine eruption. A significant decrease to 13 kg/d was estimated almost 10 days after the beginning of the eruption, followed by a sudden increase to 38 kg/d several days before the largest seismic event of the volcanic crisis ($M = 4.6$) occurred on November 11. On 5 March, the submarine eruption was over, but the volcanic process that started in mid-July 2011 had not finished. By the end of June 2012, a new seismic unrest episode occurred, accompanied by the highest deformation rate measured in the island during the unrest period. Within this phase, a new increase on the diffusive helium emission (up to 20 kg/d) was observed.

Helium emission data measured in El Hierro 2011-2012 volcano-seismic unrest demonstrate that diffuse helium surveys is a powerful tool for volcano monitoring. The geochemical parameters presented here are extremely important for forecasting the onset of volcanic unrest and subsequent volcanic eruptions, mainly when magma migrates aseismically, i.e., silently, toward the surface.