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Monitoring quiescent volcanoes by diffuse He degassing: case study Teide volcano

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Tenerife (2,034 km^2), the largest of the Canary Islands, is the only island that has developed a central volcanic complex (Teide-Pico Viejo stratovolcanoes), characterized by the eruption of differentiated magmas. This central volcanic complex has been built in the intersection of the three major volcanic rift-zones of Tenerife, where most of the historical volcanic activity has taken place. The existence of a volcanic-hydrothermal system beneath Teide volcano is suggested by the occurrence of a weak fumarolic system, steamy ground and high rates of diffuse CO_2 degassing all around the summit cone of Teide (Pérez et al., 2013). Diffuse emission studies of non-reactive and/or highly mobile gases such as helium have recently provided promising results to detect changes in the magmatic gas component at surface related to volcanic unrest episodes (Padrón et al., 2013). The geochemical properties of He minimize the interaction of this noble gas on its movement toward the earth's surface, and its isotopic composition is not affected by subsequent chemical reactions. It is highly mobile, chemically inert, physically stable, non-biogenic, sparingly soluble in water under ambient conditions, almost non-adsorbable, and highly diffusive with a diffusion coefficient $\sim$10 times that of CO_2. As part of the geochemical monitoring program for the volcanic surveillance of Teide volcano, yearly surveys of diffuse He emission through the surface of the summit cone of Teide volcano have been performed since 2006. Soil He emission rate was measured yearly at $\sim$130 sampling sites selected in the surface environment of the summit cone of Teide volcano (Tenerife, Canary Islands), covering an area of $\sim$0.5 km^2, assuming that He emission is governed by convection and diffusion. The distribution of the sampling sites was carefully chosen to homogeneously cover the target area, allowing the computation of the total He emission by sequential Gaussian simulation (sGs). Nine surveys have been carried out since 2006, showing an average emission rate of 8.0 kg/d. This value showed an anomalous increase up to 29 kg/d in the summer of 2010. The number of seismic events registered in and around Tenerife Island by the National Geographic Institute (IGN) reached also the highest value (1,176) in 2010. This excellent agreement between both times series suggest that the anomalous seismicity registered in 2010 was likely due to strain/stress changes caused by input of magmatic fluids beneath the central volcanic system of the island. These results suggest that monitoring of He degassing rates in oceanic volcanic islands is an excellent early warning geochemical precursory signal for volcanic unrest.

References

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