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Continuous monitoring of diffuse CO_2 degassing for the volcanic surveillance of Taal volcano, Philippines

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Taal Volcano in Southwest Luzon, Philippines, lies between a volcanic arc front facing the subduction zone along the Manila Trench and a volcanic field formed from extension beyond the arc front. Taal Volcano Island is formed by a main tuff cone surrounded by several smaller tuff cones, tuff rings and scoria cones. This island is located in the center of the 30km wide Taal Caldera, filled by Taal Lake. Observing changes in the CO_2 discharge rate is an important part of volcanic monitoring programs, because CO_2 is released by progressive depressurization of magma during ascent and reach the surface well before their parental magma. Diffuse CO_2 degassing studies at Taal have demonstrated to be sensitive to processes of magmatic intrusion beneath the volcano (Arpa et al., 2013). The maximum CO_2 emission rate measured to date in a volcanic lake occurred two months before the strongest seismic activity recorded during a seismo-volcanic unrest period. We report here the results of 2 years time series of continuous monitoring of diffuse CO_2 emission in an hourly basis by means of an automatic geochemical station located at the northern portion of main crater rim. The aim of this study was to monitor in a continuous mode the diffuse CO_2 degassing and to improve the early warning system of the volcano. The 2016-2017 time series shows CO_2 efflux values in the range 20-690 $g{\cdot}m^{-2}{\cdot}d^{-1}$. Meteorological variables model diffuse CO_2 emission with periods of 12h and 24h. Although short-temp fluctuations in the diffuse CO_2 emission time series were partially driven by meteorological parameters, the main CO_2 efflux changes were not driven by fluctuations of meteorological variables such as wind speed or barometric pressure and seem clearly to be associated with fluid pressure fluctuations in the volcanic system. Seismic sequence occurred on early April, and one intense seismic event occurred on August, affecting the Philippine province of Batangas and other nearby areas. The mayor earthquakes occurred on April 4 (M5.5), April 8 (M5.6 and M5.6) at hypocentral depths of 7, 27 and 8km, respectively, and April 11 (M6.3) at depth of 177km. In 14 March, 2017, just around 3 weeks before three strong earthquakes occurred in Batangas, a sharp increase of CO_2 emission from $\sim$0.1 up to 1.1 $kg{\cdot}m^{-2}{\cdot}d^{-1}$ in 9 hours was measured and since that date, average value increased from 144 to 300 $g{\cdot}m^{-2}{\cdot}d^{-1}$. In 14 July, diffuse CO_2 efflux showed a sharp increase up to 1.2 $kg{\cdot}m^{-2}{\cdot}d^{-1}$, one month before the intense seismic event occurred on August. These results show the potential of applying continuous monitoring of soil CO_2 efflux to improve and optimize the detection of early warning signals of future volcanic unrest episodes at Taal volcano and to detect geochemical precursory signals of tectonic seismic events. Other geophysical or geochemical evidence are needed to confirm these statements.

Arpa et al., 2013, Bull Volcanol 75:747.