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Changes of soil CO_2 efflux in active volcanic-hydrothermal systems due to anthropogenic activities: implications for volcano monitoring

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San Vicente or Chichontepeque (2,180 m a.s.l.) is a composite andesitic volcano located 50 Km east of San Salvador. Its paired edifice rises from the so-called Central Graben, an extensional structure parallel to the Pacific coast, and has been inactive for the last 3000 yrs. Fumaroles (98.2 ^{0}C) and hot spring waters are present along radial faults at two localities on the northern slope of the volcano (Aguas Agrias and Los Infiernillos Ciegos). CO_2 is the most abundant component in the dry gas (>90%) and its mean isotopic composition ($\delta^{13}C(CO_2)$= -2.11 per mil vs PDB and $^3He/^4He$ of 6.9 Ra) suggests a magmatic origin for the CO_2. These manifestations are supposed to be linked to a 1,200 m depth 250 ^{0}C reservoir with a CO_2 partial pressure of 14 bar extended beneath the volcano (Aiuppa et al., 1997). In February 13, 2001, a 6.6 magnitude earthquake with epicenter about 20 Km W of San Vicente damaged and destroyed many towns and villages in the north area of the volcano causing some deceases. Searching for any link between the seismic activity and changes in the diffuse CO_2 degassing at San Vicente, an NDIR instrument for continuos monitoring of the diffuse CO_2 degassing was set up at Aguas Agrias in March 2001. Soil CO_2 efflux and several meteorological and soil physical variables have been measured in an hourly basis until present. Soil CO_2 efflux ranged from non detectable values up to 4442 g m^2 d^{-1} and showed a mean of 1521 g m^2 d^{-1}. Salazar et al., (2002), observed a significant increase in soil CO_2 efflux (2500 g m^2 d^{-1}) before the 5.1 magnitude earthquake occurred on May 2001. Strain changes and/or fluid pressure fluctuations

in the crust were hypothesized as responsible for the observed variations. A higher sharp increase on the CO_2 efflux rate from mean value up to the maximum measured value (4442 g m^2 d^{-1}) was observed in October 6, 2003, three days before the activation of an geothermal exploration well located several hundred of meters from the observation point. CO_2 efflux reached background values by November 11th, 2003. This acute increment on CO_2 efflux was not correlated with high frequency minor fluctuations related to meteorological and soil physical variables and with the seismicity registered during the period September-November 2003. The observed increase on the soil CO_2 efflux suggest that anthropogenic activities which might modify the physical and chemical conditions of a volcanic-hydrothermal system can trigger changes in the fluid pore-pressure and enhance the uprising of hydrothermal fluids to the surface environment. This observed phenomenon must be considered in the volcanic monitoring programs in order to distinghuish anthropogenic from natural processes affecting the volcanic-hydrothermal systems.