Prévision des éruptions volcaniques par l'analyse chimique des fluides hydrothermaux d'arc insulaire : Guadeloupe (Petites Antilles) et Nisyros (Grèce)

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This study investigates two hydrothermal systems in volcanic island arcs, Guadeloupe (Lesser Antilles) and Nisyros (Greece). At Guadeloupe spring water and fumarolic gas samples were collected in 1997, while at Nisyros three surveys were undertaken (1997, 1998 and 1999), covering fluid sampling, diffuse soil CO2 flux, soil temperature and soil thermal gradient determinations.
The chemical and isotopic composition of gas emissions (H2O, CO2, H2S, H2, N2, CH4, CO, Ar, He, dD(H2O), d18O(H2O), d18O(CO2), d13C(CO2), and d34S(H2S)) and thermal waters (Na, K, Mg, Ca, HCO3, Cl, SO4, SiO2, B, dD(H2O), d18O(H2O), and d34S(SO4)) is used, after merging these new data sets with existing data, to elaborate a geochemical model for both hydrothermal systems, which provide the necessary basis for adequate volcanic surveillance. In addition, based on diffuse soil CO2 and soil temperature measurements, the release of hydrothermally related thermal energy is quantified for the Nisyros system.
In both systems, Guadeloupe and Nisyros, fumaroles discharge hydrothermal fluids lacking in highly acid gases, such as SO2, HCl and HF. Their outlet temperatures are buffered to 100 ºC. However, isotopic results point to a contribution of andesitic magmatic water. Water stable isotopes indicate boiling, mixing and condensation processes occurring in the subsurface. Assuming chemical equilibrium between gas constituents in the aquifer, and quenching of this equilibrium during upflow of the fluids, the equilibrium temperature of the aquifer and the temperature of vapor separation are estimated. Considering these geothermometric findings, and the alteration phenomena of the gas discharges the isotopic composition of the parent geothermal liquid is traced back for both systems.
The thermal spring system at La Soufrière volcano (Guadeloupe) includes (1) sulphate waters produced through absorption of hydrothermal vapors into shallow groundwaters, (2) Ca-Na-Cl springs which testify for mixing of sulfate waters with deep Na-Cl hydrothermal liquids and (3) conductively heated groundwaters. High-salinity Na-Cl geothermal liquids circulate in the Bouillante geothermal reservoir of Guadeloupe at temperatures close to 250 ºC. These liquids undergo boiling and mixing with groundwater and/or seawater before they discharge as Na-Cl thermal springs. The Na-Cl thermal waters discharging along the coast of Nisyros seem to be fed by seawater with minor contributions of condensed steam outflows from the geothermal system.
Repeated surveys of diffuse soil CO2 flux, soil temperature and soil thermal gradient surveys in the southern part of the Lakki plain of Nisyros allow to elaborate several distribution maps of these parameters. These combined measurements - CO2 flux, soil temperature and soil thermal gradient - permit to understand the mechanism of heat transfer through the soil and to quantify the flux of hydrothermally related thermal energy released from the surveyed area. It amounts to 58MW for 1.3 km2. No significant time variations in CO2 and thermal fluxes took place from 1997 to 1999, suggesting that the hydrothermal system was close to steady state conditions during that time.