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Carbon dioxide degassing at Bagni San Filippo (Tuscany, Italy): quantification and modelling of gas release

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The area of Bagni San Filippo (BSF) is located in the NW periphery of the Mt. Amiata volcano, in the eastern side of the Siena-Radicofani graben, is part of the Mt. Amiata geothermal region and is located within a regional CO_2 flux anomaly interesting the whole Perityrrhenian sector of central Italy. The geological framework of BSF is characterized by outcrops carbonate-evaporite triassic-giurassic formations in the western side and by liguides flysch overlying the carbonate-evaporite sequence on the eastern side. BSF is affected by a strong and widespread CO_2 emission that emerges as vents, diffuse soil emissions, large travertine deposits and as CO_2 rich thermal water outflows of HCO_3-SO_4-Ca-Mg composition and temperatures from 23 to 48˚C. The strong CO_2 emission represents a natural hazard in the area as indicated by the lethal accidents occurred to humans also in recent times. A multi-parametric geochemical study of the BSF area was performed in 2003-2004 in order to quantify the CO_2 degassing, to define the conceptual model of the degassing process and to constrain a physical-numerical modeling of the system. A general soil CO_2 flux survey showed the presence several degassing structures that were investigated by specific surveys. The mapping of CO_2 flux, by geostatistical method, highlighted that the larger CO_2 degassing structures are associated to faults involving the carbonate formations and to areas of actual or “fossils” water outflow (i.e., where travertine outcrops). A total CO_2 release of about 150-200 t/d was estimated. A geochemical reaction pat model of water-rock-gas interaction was then applied to the thermal waters in order to model the dissolved carbon content and the composition of dissolved gas. The comparison of experimental data with the model supports that the thermal waters are the result of the

mixing between shallow groundwater and a hot, CO_2 rich, vapour phase reasonably derived by an underling geothermal system. Coupling together the results of the CO_2 flux survey with geochemical, hydrogeological and geological data the following conceptual model was derived for upper part of BSF system: the groundwater recharge, from local carbonate outcrop, infiltrates and circulates in the buried carbonate aquifers where it is heated (up to 60˚C) and enriched in CO_2 (up to 10 bar of P_{CO2}) by the input of the geothermal vapor. This anomalous and relatively shallow aquifer feeds both CO_2 soil degassing and the thermal water outflow. The physical feasibility of such conceptual model was successfully tested by a physical-numerical simulation using the TUOGH2 code.