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# The effect of steam-heating processes on the chemical and isotopic composition of the shallow thermal aquifer in Vulcano Island (Aeolian Arc, Sicily).

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We report on a comprehensive study of major-ion chemistry, dissolved gases, and stable isotopes measured in water wells at Vulcano Island since 1988. Particularly, we focus on chemical and hydrological modifications of groundwaters observed in the last two decades, interpreted according to a quantitative model describing steam condensation and boiling phenomena in shallow water bodies (Federico et al., 2010). According to this model, we infer that (i) strong isotope enrichment observed in some shallow thermal waters can result from an increasing mass rate of condensing deep vapor, even in water being meteoric in origin; (ii) the high $pCO_2$ measured in the coldest and peripheral waters are explained by the progressive $CO_2$ enrichment in the vapor phase during multistep boiling; and (iii) the high Cl− and SO4– contents in the hottest waters can be attributed to the direct condensation (single-step) of volcanic vapor. The model also takes into account both the mass fluxes and the compositions of the involved endmembers (steam and shallow groundwater), which provides important inferences on the modifications observed during the periods of increasing mass and heat input from depth occurred at Vulcano Island. The volcanic crisis that occurred in 1988–1993 profoundly affected the composition of some thermal wells that were more-directly affected by ascending vapour. In particular, higher Cl−, SO4–, and $HCO_3$− contents, temperature, and $pCO_2$ values were measured. These variations are all explained by a different composition of the vapor entering the aquifer paralleled by a higher mass rate relative to the shallow meteoric endmember. Minor effects on the shallow thermal aquifer are observed during the following periods of increasing heat and mass flux from depth, mostly recorded in the crater area. This implies that the shallow thermal aquifer is affected by magmatic fluids ascending along central conduits only when there is a significant increase in the heat and mass fluxes from depth, which are able to vaporize the deep hydrothermal aquifer and modify the chemical and isotopic compositions of a larger portion of the volcanic edifice. Otherwise, the shallow thermal aquifer is chiefly affected by the vapor separating from the 400°C- hydrothermal system and, therefore, by its P-T conditions. On these grounds, once apportioned the effect of rainwater, we tentatively evaluate the effect of variations of physico-chemical conditions of the hydrothermal aquifer on both the water level and the composition of sampled thermal waters.