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Estimation of the magmatic gas and heat flux through the Etnean volcanic aquifer

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Etna volcano, Italy, hosts one of the major groundwater systems of the island of Sicily. Waters circulate within highly permeable fractured, mainly hawaiitic, volcanic rocks. Aquifers are limited downwards by the underlying impermeable sedimentary terrains. Thickness of the volcanic rocks generally does not exceed some 300 m, preventing the waters to reach great depths. This is faced by short travel times (years to tens of years) and low thermalisation of the Etnean groundwaters. Measured temperatures are, in fact, generally lower than 25 °C. But the huge annual meteoric recharge (about 0.97 km^3) with a high actual infiltration coefficient (0.75) implies a great underground circulation. During their travel from the summit area to the periphery of the volcano, waters acquire magmatic heat together with volcanic gases and solutes through water-rock interaction processes.
In the last 20 years the Etnean aquifers has been extensively studied. Their waters were analysed for dissolved major, minor and trace element, O, H, C, S, B, Sr and He isotopes, and dissolved gas composition. These data have been published in several articles. Here, after a summary of the obtained results, the estimation of the magmatic heat flux through the aquifer will be discussed.
To calculate heat uptake during subsurface circulation, for each sampling point (spring, well or drainage gallery) the following data have been considered: flow rate, water temperature, and oxygen isotopic composition. The latter was used to calculate the mean recharge altitude through the measured local isotopic lapse rate. Mean recharge temperatures, weighted for rain amount throughout the year, were obtained from the local weather station network. Calculations were made for a representative number of sampling points (216) including all major issues and corresponding to a total water flow of about 0.315 km^3/a, which is 40% of the effective meteoric recharge. Results gave a total energy output of about 140 MW/a the half of which is ascribable to only 13 sampling points. These correspond to the highest flow drainage galleries with fluxes ranging from 50 to 1000 l/s and wells with pumping rates from 70 to 250 l/s. Geographical distribution indicates that, like magmatic gas leakage, heat flow is influenced by structural features of the volcanic edifice. The major heat discharge through groundwater are all tightly connected either to the major regional tectonic systems or to the major volcanic rift zones along which the most important flank eruptions take place. But rift zones are much more important for heat upraise due to the frequent dikes injection than for gas escape because generally when dikes have been emplaced the structure is no more permeable to gases because it becomes sealed by the cooling magma.