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# 4He and heat balance as groundwater-dating tools: the study case of Sciacca thermal basin, Sicily (Italy)

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Rare gas content measurements in groundwater of Sciacca Thermal Basin (STB), western Sicily (Italy), showed an excess of helium respect to a typical water in equilibrium with atmosphere (ASW). The isotopic composition of such helium is 2.9 Ra (where Ra is the 3He/4He ratio in atmosphere), displaying an excess of 3He which cannot be explained by cosmogenic production/accumulation but is attributed to the addition of mantle-derived He. Taking into account that helium isotopes are not much sensitive to degassing processes from water , the measured isotopic composition can be considered representative of the area.

The isotopic signature of the dissolved heavier noble gases (i.e. Ne, Ar) constrains their atmospheric origin, but their elemental abundances are lower than expected for an ASW. This is interpreted in terms of elemental fractionation during degassing processes. We re-calculated the residual fraction (F) of noble gases in groundwater and the pristine amount of dissolved atmospheric noble gases on the basis of the classical liquid-gas phase portioning model. Such data allowed us to compute the correct amount of pristine 4He dissolved into the thermal water. Then, once known the He flux, we estimated the age of STB groundwaters as a function of the physical parameters of the aquifer.

Tritium measurements carried out in these waters give us values below 1TU highlighting the “old” nature of waters. Hence here we used radiogenic helium as tracer of groundwater age and check the result with the groundwater age computed by using a new dating method based on heat balance equation. On the basis of the calculated total amount of helium dissolved into the groundwaters and its isotopic ratio we compute the amounts of radiogenic dissolved helium. Thus known the 4He flux we dated the STB groundwater as function of the physical parameters of the aquifer.

It is well known that the validity of estimated groundwater residence time depends on the accurate evaluation of 4He accumulation rates and some hydrological parameters such as porosity and thickness of aquifers. Thus, in order to better constrain the water age, we used an other dating approach based on heat balance equation. Firstly, we analysed the complete sequence of water transport through the deep thermal aquifer system, from its recharge to the discharge. The ratio between the internal energy of a defined volume of water and the net heat conducted out allows to estimate the residence time of the water in each elementary volume.

The ages of the STB groundwaters arising from the two independent approach are comparable and the resident time results older than tens of thousands of years.