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Geochemical composition of Casaglia geothermal fluids and its relationships with the tectonic regime (Emilia-Romagna Region, Italy)

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In this study the geochemical composition of the fluids belonging to the geothermic reservoir of Casaglia is presented. The site is located few kilometers northward of Ferrara, probably the only city in Italy whose heating system is fed by the geothermal heat near the top of the Dorsale Ferrarese, a structural anticline raising the Mesozoic limestones up to few hundred meters below the surface. Measurements of the chemical and isotopic composition of the gas phase (e.g., CO_2 and noble gas) were carried out, together with a full characterization of the physico-chemical parameters and the chemistry of the water phase.

Fluids derive from a well at a depth of about 322+15meters and the temperature of the emerging water is of 78,6 °C, pH of 6.29 and Eh of -470 mV. Salinity is up to 115.6 mS/cm with a TDS varying between 71024 mg/L and 73718 mg/L. The hydrochemical facies is identified as clorurato-alkaline and the Cl/Br ratio suggest mixing with fossil brines. dD and $d^{18}O$ vary from 4.70 to 5.02 and from -12.0 to -12.2 respectively. The volatile phase is mainly composed of N_2 (24.9-40.5 %),CH_4 (21.1-29.5 %) and CO_2 (37.1-18.6 %), with $d^{13}C(CO_2)$, $d^{13}C(CH_4)$ and $dD(CH_4)$ varying from -4.4 to -3.7 ‰, from -41.7 to 41.2 ‰ and from -152 to -171 ‰, respectively. The He amounts are extraordinary high (up to 3956 ppm) with a $^3He/^4He$ of 0.02Ra unequivocally pointing to a crustal origin (e.g., Caracausi & Sulli, 2019). The $^{40}Ar/^{36}Ar$ ratios span the range 300-374, being very close to the same ratio in atmosphere.

Such high He concentration cannot be explained by a simple steady-state crustal degassing, taking into account the Th and U contents of the sedimentary cover and the metamorphic basement (Coltorti et al. 2011) which lead also to consider that the thermal state of the Casaglia reservoir involve the entire crustal thickness and not only the Mesozoic carbonate succession that hosts the reservoir itself.

It is inferred that under an active tectonic regime, as it is that where Casaglia is located, the formation of micro-fracturation, due to the field of stress generated by the local seismicity, increases the He release from the rocks and can contribute to the observed He excess in the geothermal reservoirs (e.g., Buttitta et al., 2020). In this respect, the fault system of Dorsale

Ferrarese contributes to generate a preferential pathway for rising fluids with consequent mixing phenomena and provides a reasonable explanation about the presence of this high He content in the reservoir.

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