Fluid geochemistry of the vicano-cimino hydrothermal reservoir (central italy): implications for geothermal exploration

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The Vicano-Cimino Volcanic District (VCVD), located in the peri-Tyrrhenian sector of central Italy, is characterized by Pleistocenic volcanic products derived from two different magmatic cycles: i) the acid cycle, consisting of a SiO2-rich magma of the Tuscan Magmatic Province, encompassing the Cimino Volcanic District, and ii) the K-alkaline cycle of the Roman Magmatic Province, encompassing the Vicano Volcanic District. The volcanic products overlie a sedimentary sequence constituted by Plio-Pleistocene clays, Cretaceous-Oligocene flyschoid sediments and a thick Mesozoic carbonate-evaporite formation containing a pressurized hydrothermal reservoir.

Extensive exploration surveys were carried out in this area in the seventies to nineties for geothermal purpose although the VCVD is presently not exploited. The presence of thermal waters and of anomalous heat flow, together with demographical growing in the last years, makes this site a suitable location for applications of the geothermal resource.

On the whole, 333 fluid discharges (cold waters, thermal waters and bubbling pools) and 25 gas emissions were collected for chemical and isotopic compositions. Water chemistry points out the presence of two main reservoirs at different depths. The deepest one is hosted in the Mesozoic formation and shows a Ca-SO4(HCO3) composition, likely produced by high temperature fluid-rock interaction involving Triassic anhydrite layers at the base of the carbonates. The shallow aquifer is hosted within the volcanic domain and has a Ca-HCO3 composition. deltaD and delta18O values suggest that both reservoirs are fed by meteoric waters.

Carbon dioxide, largely dominating the free gas phase associated to both cold and thermal springs, has a twofold origin, being related to i) mantle degassing and ii) thermo-metamorphic reactions occurring in the carbonate reservoir. The R/Ra values range from 0.41 to 1.14 and suggest relatively low contribution of mantle-derived fluids with respect to those gases produced in the crust. The 13C/12C ratios of CH4 and 34S/32S ratios of H2S are likely indicating an origin for these two gas species mainly controlled by high temperature reactions occurring within the Mesozoic reservoir and involving the reduction of CO2 and that of the Triassic anhydrites, respectively. Furthermore, delta15N-N2 isotopic data point out to a non-atmospheric source for N2 likely related to high-temperature alteration of organic-rich meta-sedimentary rocks of the Palaeozoic basement below the Mesozoic reservoir.

Gravimetric and structural data suggest that the spatial distribution of the deep-originated fluid discharges corresponds to the boundaries between positive and negative gravity zones, which are interpreted as extensional faults bordering buried structural highs of the carbonate basement.

Gas geothermometric calculations have allowed to estimate reservoir temperature in a range between 250 and 300 degrees.