

Origin and geochemical processes controlling the chemistry of thermo-mineral waters from the Eastern sectors of the Alps, pre-Alps and Po plain (north Italy): a first geothermal potential assessment

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Geothermal prospection has traditionally been focused on the central-southern Italy area, whereas northern Italy (i.e., from northern Apennines to Alps, including the Po Plain) has received scarce attention, notwithstanding the occurrence of several thermal discharges would make low-medium enthalpy geothermal exploration promising.

This study aimed to fill this gap with an extensive survey of geochemical and isotope parameters on thermo-mineral waters in the eastern Alps and pre-Alps, including the northeastern sector of the Po plain. The goals were: (i) to shed light on water-rock interaction processes controlling the chemistry of these waters; (ii) to provide insights into geothermal potential related to the different hydrothermal systems of the study area; (iii) to contribute to the development of a national public geochemical data portal for geothermal manifestations in central-northern Italy supported by the EMOTION Project.

A total of 67 water samples from springs, wells and boreholes were collected. The total dissolved solid values ranged from around 100 to 20,000 mg/L whilst water temperatures varied from < 10 °C to about 65 °C with the highest temperatures in waters from southern Garda Lake, the Grado-Tagliamento area and Bormio Terme. The high-variable chemical composition of water samples, including the Na-Cl, Ca-SO₄, Ca-HCO₃ and Na-HCO₃ facies, was likely due to water-rock interactions involving different geological formations, as also supported by minor element patterns. The δD - and $\delta^{18}O$ -H₂O values indicated a predominant meteoric origin of all waters except those from the Grado area affected by mixing with seawater, being close to the coastline. Dissolved gases spanned from N₂- to CO₂-dominated, with a few samples showing a significant CH₄-enrichment. Relatively heavy $\delta^{13}C$ values in CO₂ and total dissolved inorganic carbon shown by samples from Rabbi, Peio and

Recoaro Terme inferred C-inputs from metamorphic reactions of limestones. The high R/Ra values (~ 3) characterising Recoaro Terme gases imply a significant contribution of mantle He, possibly favoured by the occurrence of deep faults. Equilibrium temperatures estimated with the SiO₂ geothermometers reveal temperatures of interest for geothermal exploration (around 70-100 °C) in three different areas: i.e., Southern Garda Lake, the Grado-Tagliamento area and Bormio Terme.