

Conceptual and numerical hydrogeological modeling of the Euganean Geothermal area (NE, Italy) (Fabbri, Piccinini, Zampieri)

The aim of the project is to combine local and regional geological, structural and hydrogeological data knowledge, to improve the conceptual model of deep fluid circulation in the Euganean Geothermal System (EGS). For the first time, a 3D numerical model of the conceptual model will be developed taking into account the density variability of hot deep fluids. The model will be implemented combining all the available data on: i) the geological and hydrogeological setting of the Euganean Geothermal area (i.e., stratigraphic logs of the more than 400 boreholes, geological maps of the subsurface, daily potentiometric levels, potentiometric level maps of the thermal aquifer, temperature maps of the exploited water, vertical logs of the temperature, monthly rate of exploitation in the field); ii) the geochemistry of the Euganean thermal waters (i.e., ratios between elements, oxygen isotopic data, isotopical fluids rising times); iii) geological and structural data on the area involved by the thermal water flow. Due to the extreme heterogeneity of experimental data (regional and field scale data) the first problem will be to homogenize the huge amount of information. Subsequently, a hydrogeologically acceptable conceptual model with a conscious simplification will be reproduced by a numerical model at regional and/or field scale to verify if its physical results could be in accordance with the hydrogeological model.

This research will be founded by MODellazione Idrogeologica del bacino Termale Euganeo (MOITO) project

State of the Art

The Euganean Geothermal Field (EGF) is one of the most important thermal fields in northern Italy. The EGF is located on a plain band of approximately 25 km² to the southwest of Padova and to the east of the Euganei Hills (Veneto Region, NE Italy) and has been well known since the Roman period. The thermal field comprises the spa towns of Abano Terme, Montegrotto Terme, Battaglia Terme and Galzignano Terme, where more than 400 wells have been drilled since the 1960s due to increasing demand for the thermal waters. Approximately 250 wells are presently active and exploit 17*10⁶ m³/y of thermal water. The water is primarily used for health and spa purposes and secondarily to warm hotels and for tropical flower-growing.

The geological setting of the EGF has been reconstructed since the 1990s using the stratigraphic logs of drilled wells, some of which reach a depth of 1000. The thickness of the Quaternary alluvial cover ranges from a few meters (i.e., Battaglia Terme and Galzignano Terme and locally at Montegrotto Terme) to approximately 200 m (Abano Terme). The subsurface of the EGF is fragmented into a mosaic of blocks by a network of high-angle faults (main directions: NNE-SSW, E-W, NNW-SSE). A similar pattern of open fractures (main directions: NNE-SSW, ESE-WNW, NW-SE) deforms a travertine mound (Montirone Hill) located in Abano Terme.

From a regional point of view, the EGF is located along the Schio-Vicenza fault system (SVFS), which extends for approximately 120 km in the Veneto alluvial plain from the foot of the Prealps to the Po delta. This system is composed of NW-SE to NNW-SSE trending, NE-dipping, high-angle faults buried beneath the Quaternary alluvial cover of the Veneto plain, and it bounds the northeastern part of the Adria plate indenter to the west.

The Euganean thermal fluids are characterized by: i) temperatures from 60°C to 86°C; ii) basic pH from 6.3 to 7.4, which is independent from temperature; iii) high values of total dissolved solids from 3.5 to 6 g/L with the principal constituents being primarily Cl⁻ and Na⁺ (70 wt.%) and secondarily SO₄²⁻, Ca²⁺, Mg²⁺, HCO₃⁻ and SiO₂; iv) stable isotope compositions that are more negative than the local meteoric water (Euganean thermal water: δ¹⁸O from -11.5‰ V-SMOW to -10.1‰ V-SMOW and δD from -84.8‰ V-SMOW to -71.5‰ V-SMOW; local meteoric water: δ¹⁸O of approximately -8.5‰ V-SMOW and δD of approximately 55±5‰ V-SMOW); and v) absent or very low ³H content.

The stable isotope data of the Euganean fluids reveal a common meteoric origin and suggest an infiltration area located at approximately 1500 m a.s.l.. The parent meteoric water acquires its high salinity and chlorinity through prolonged leaching reactions with the sedimentary formations of the reservoir. In particular, the quite constant Ca/SO₄ ratio (0.46 ± 0.4), which is in agreement with the gypsum-anhydrite reference value (~ 0.42), suggests a circulation of the thermal water through evaporitic formations. The reservoir equilibrium temperatures are estimated using the SiO₂ and K/Mg geothermometers, which indicate an equilibration temperature from 80 to 100°C. The ³H and ¹⁴C measurements suggest a residence time greater than 60 years and probably in the range of a few thousand years.

The Euganean thermal waters in the EGF are mainly exploited from highly fractured horizons located at a depth between 300 m and 500 m within the Maiolica Formation. The transmissivity of the aquifer was estimated between 13 m²/d and 500 m²/d. The potentiometric level of this aquifer is a few meters below ground level, and its annual trend shows anthropic seasonal variations related to the touristic seasons. As a matter of fact, a decrease of the level occurs during spring and autumn, when there is a higher exploitation of thermal waters related to the high rate of incoming tourists, whereas an increase takes place during winter and summer, when the demand for thermal water is lower. Other secondary thermal aquifers are found at different depths: i) the sandy layers of the Quaternary alluvial cover host thermal waters with slightly lower temperatures (i.e., 48°C at 56 m below ground level and 79°C at 136 m below ground level) that were exploited in the recent past but are presently not used ; and ii) the fractured layers, located at approximately 800-1000m depth in the Calcari Grigi Formation and in upper part of the Dolomia Principale Formation, form a deeper thermal aquifer bearing thermal waters with higher temperatures (approximately 80°C) and a potentiometric level above ground level due to the still-moderate exploitation. All aquifers (i.e., sandy aquifers and rocky aquifer at different depth) exhibit similar seasonal variations of the potentiometric level, suggesting that they are hydraulically connected.