New insights from analyses of geophysical data in the Northern Apennine buried structures for evaluation of their geothermal potential

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Geothermal energy is arguably the most attractive of low-CO2 renewable resources, being broadly distributed and available in every period of the year. The main aim of the InGEO project (*Innovation in GEOthermal resources and reserves potential assessment for the decarbonisation of power/thermal sectors*) is to develop an innovative exploration workflow integrating geophysical data and other direct and indirect information, organized to make available a sort of decision support system of geothermal projects. To this purpose, we chose as a target area the Northern Apennine buried structures belonging to the Romagna and Ferrara Folds (RFF). This area extends from the termination of the Emilia Folds in the West to the Adriatic coast in the East and from the outcropping edges of the Northern Apennines in the South to the undeformed Po foredeep in the North. The RFF area has been the subject of previous geothermal studies revealing relatively low geothermal gradients within the deep carbonate units (on average 14 °C/km) and more significant thermal gradients (on average 53 °C/km) in the overlying impermeable formations (Pasquale et al., 2013). This feature in temperature distribution with depth is clear evidence for fluid thermal convection occurring in the deep-seated carbonate units of Mesozoic age, which constitutes the local geothermal reservoir.

The shallow crust of this area has been investigated by several previous studies and through a total of 535 deep exploratory wells (VIDEPI database: https://www.videpi.com/videpi/videpi.asp), having final depths ranging from 0.5 up to 6.5 km below ground level. They provide essential information, concerning lithostratigraphy, temperatures measured during drilling stops and geophysical logs, commonly electrical resistivity, gamma ray and sonic. Several geophysical investigations, recently carried out in the Alps and Po plain, revealed both the shallow ad deep structures of the study area, in terms of lateral variations of Bouguer anomalies, seismic velocities, and main discontinuities (Nouibat et al., 2023; Zahorec et al., 2021). The analyses of the data collected revealed a good correspondence between the low seismic velocities, characterizing the shallow crust of the RFF, and the negative Bouguer anomalies. We reconstructed the Moho depth of the area, estimating the depth of the iso-velocity contour of 4.1 km/s (Nouibat et al., 2023) and observed its deepening from NE to SW, towards the Apennines, from ~27 km to ~48 km. Seismic tomography of the upper mantle (Rappisi et al., 2022) reveals that the velocity in the shallow and deep lithosphere is low in the central part of the study area, possibly related to a local asthenospheric upwelling and tends to increase beneath the Apennines.

The results of this ongoing research will be the input of the thermal model and contribute to the development of an open-source and web-based GIS tool, and to the calculation of the deep geothermal energy potential for both hydrothermal resources and deep heat exchangers.

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