A 3D Geological Model of the Romagna and Ferrara Folds, (Eastern Po Plain) for advanced deep geothermal exploration

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Geothermal energy is a sustainable and environmentally friendly solution for power generation and district heating/cooling, offering continuous availability throughout the day and year. Despite its global potential, targeted strategies are essential for advancing geothermal resource exploitation.

The InGEO project ("Innovation in GEOthermal resources and reserves potential assessment for the decarbonisation of power/thermal sectors"; www.ingeo.cnr.it) seeks to develop an innovative exploration workflow integrating geological, geophysical, thermophysical, and other datasets to enhance the characterization of potential geothermal reservoirs. This approach can support strategic planning, with scientific information voted to exploit deep geothermal resources in Italy.

Deep-seated carbonate reservoirs, forming the basement of sedimentary basins, are key targets for geothermal development in Italy, they are the main focus of the analyzed case study. In the eastern Po Plain, the buried Romagna and Ferrara Folds (RFF)—stretching from the Emilia Folds to the Adriatic coast and from the northern Apennines to the undeformed Po foreland—show significant geothermal gradient variations, indicative, in some cases of low gradient, of possible convective heat flow in deep carbonate units. Pasquale et al. (2013) reported low geothermal gradients (14 °C/km) within the carbonate reservoir and higher gradients (53 °C/km) in overlying impermeable formations, confirming thermal convection within Mesozoic carbonate units.

To investigate this area, we digitised and analysed a large amount of data, considering over 200 seismic surveys (VIDEPI database, www.videpi.com), 700 deep boreholes (>1500 m deep; CNR database, www.geothopica.igg.cnr.it), and 160 borehole logs (sonic and lithological; Livani et al., 2023), covering ~22,500 km². This extensive dataset underpins the development of a detailed 3D geological model that delineates the thickness variations of major lithological units to a depth of ~10 km. Seismic reflection interpretations, constrained by available well stratigraphy, were used to identify key lithological unconformities.

The resulting 3D geological model represents a fundamental tool for assessing the basin's geothermal potential and refining exploration workflows applicable to analogous basins. The final

obtained geothermal model will serve as a benchmark for evaluating geothermal resources and as input for testing the consistency of various geophysical datasets (Basant et al., 2025) and an open-source, web-based GIS tool for multiple applications.

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References

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