Analyses, interpretation, and integration of boreholes data and seismic reflection profiles into a 3D Geological Model of the Romagna and Ferrara Folds, (Eastern Po Plain) for the evaluation of geothermal resources

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Keywords: geothermal energy, Romagna and Ferrara folds, ingeo project.

Geothermal energy is a constant, clean, and renewable energy source that utilizes the Earth's internal heat for different applications, such as heating, cooling, and electricity generation. However, the estimation and exploitation of this energy implies to acquire a deep knowledge of the rocks composing the reservoirs and those overlying it.

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, and other datasets to enhance the characterization of reservoir rocks and their sedimentary cover. This approach supports strategic planning for deep geothermal resource utilization in Italy.

Deep-seated carbonate reservoirs, forming the basement of sedimentary basins, are key targets for geothermal development. 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 of convective heat flow in deep carbonate units. Low geothermal gradients (14°C/km) within the carbonate reservoir and higher gradients (53°C/km) in overlying impermeable formations indicate thermal convection within Mesozoic carbonate units (Pasquale et al., 2013).

For the evaluation of the geothermal potential of the area, the implementation of a consistent 3D geological model, displaying the thickness variations of the major lithological units of the area, is crucial. To this aim, we have digitized and analyzed 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). Seismic reflection interpretations, constrained by well stratigraphy, were used to identify key lithological unconformities. Age limits maps have been obtained by interpolating well tops and interpreted seismic horizons. The uncertainties of the results increase with the age of the units, due to the decrease of the control points with depth (well tops). These preliminary maps have been converted from the TWT to depth domain, in order to obtain a consistent 3D geological model. The obtained results were compared with those of the previous study of Livani et al. (2023), which focused on the on-shore part of the study area. Our 3D model will be used to constrain the seismic velocities and densities distribution in depth, obtained from the analyses and interpretation of different geophysical datasets (Basant et al., 2025) and become part of a crustal model public available for multiple applications, such as geothermal resources evaluation.

Basant et al. (2025) - Joint geophysical modelling constrained by geological and petrophysical data for assessing the geothermal energy potential of the Romagna and Ferrara folds (RFF), Eastern Po-plain. In: Congresso congiunto SIMP-SGI, Abstract book, Padova, 16-18 September 2025.

Livani et al. (2023) - Subsurface geological and geophysical data from the Po Plain and the northern Adriatic Sea (north Italy). Earth Syst. Sci. Data, 15, 4261-4293, https://doi.org/10.5194/essd-15-4261-2023.

Pasquale et al. (2013) - Evidence for thermal convection in the deep carbonate aquifer of the eastern sector of the Po Plain, Italy. Tectonophysics, 594, 1-12, https://doi.org/10.1016/j.tecto.2013.03.011.