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

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Advancing geothermal energy, the thermal energy stored within the earth's crust, supports global efforts to reduce carbon emissions and offers a sustainable solution to meet the rising energy demand. However, developing this resource requires a comprehensive assessment of the geothermal prospect to mitigate the risks and high costs associated with drilling non-productive wells. The InGEO (Innovation in GEOthermal resources and reserves potential assessment for the decarbonization of power/thermal sectors, www.ingeo.cnr.it) project seeks to develop an innovative exploration workflow for integrating geological, geophysical and petrophysical datasets that will contribute to reducing these uncertainties. The project focuses on the Northern Apennine buried - structures belonging to the Romagna and Ferrara Folds (RFF). Analysis of borehole data identified a thermal anomaly within this region attributable to deep fluid circulation within the deep-seated Mesozoic carbonate sequences. In this study, we present a joint interpretation of geophysical data. Firstly, previous seismic tomography models (Magnoni et al., 2022; Kastle et al., 2025) were integrated with sonic velocity data obtained from wells drilled in the RFF region (Livani et al., 2023) using the Fuzzy c-means method to develop a consistent cluster model. Secondly, gravity data (Zahorec et al., 2021) over the RFF region were inverted to implement a density contrast model using the GROWTH-23 inversion technique. The resulting 3D density contrast and cluster models were jointly interpreted to investigate the shallow and deep structures within the RFF region. The models were constrained with a 3D geological model (well logs, seismic lines, stratigraphic columns) and petrophysical data (thermal and acoustic measurements on rocks) obtained on outcrops also sourced from the RFF region. This information will be used as input parameters for the development of a thermal model and the implementation of an open-source and web-based GIS tool that will assess the deep geothermal resource potential for both hydrothermal resources and closed-loop deep heat exchangers solutions in Italy, but with potential to extend the approach in different geological contexts. The workflow of InGEO project will be used as a decision support system for developing geothermal projects in Italy.

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