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DERISKING GEOTHERMAL PROJECTS REUSING PRE-EXISTING OIL&GAS SUBSURFACE DATA: THE GUARDIA LOMBARDI (ITALY) CASE STUDY

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INTRODUCTION

The urgent need to achieve carbon neutrality by 2050 requires a rapid transition to green energy. In this context, geothermal energy plays a key role in low-carbon technologies for electricity production and building heating/cooling. However, its development is hindered by high exploration costs and risks. Reusing already available hydrocarbon exploration data offers a promising opportunity. Italy has significant geothermal potential, but currently meets less than 2% of its energy demand.

This study evaluates the geothermal potential of the Guardia Lombardi area (Fig. 1), characterized by high heat flow, elevated subsurface temperatures, thermal springs, CO_2 emissions, and geothermometric data at the reservoir depth (e.g., ENEL, 1987; Budetta et al., 1988; ENEL/ENI/CNR/ENEA, 1994; Duchi et al., 1995; Della Vedova et al., 2001; Chiodini et al.,

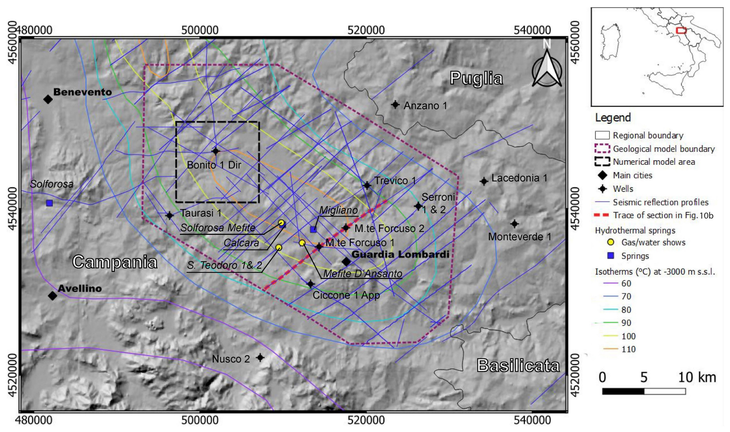


Figure 1. Study area and data location map.

METHODS

This study integrates and analyzes vintage subsurface data (well logs, core samples, and seismic reflection profiles) acquired for hydrocarbon exploration and deriving from both public (ViDEPI Project) and confidential sources. Stratigraphic, thermal, and structural analyses were performed to characterize the reservoir. The data were interpreted to build a 3D geological model of the subsurface, with time-depth conversion based on a velocity model. A numerical simulation was also conducted to assess the geothermal resource potential, supported by a detailed cost evaluation.

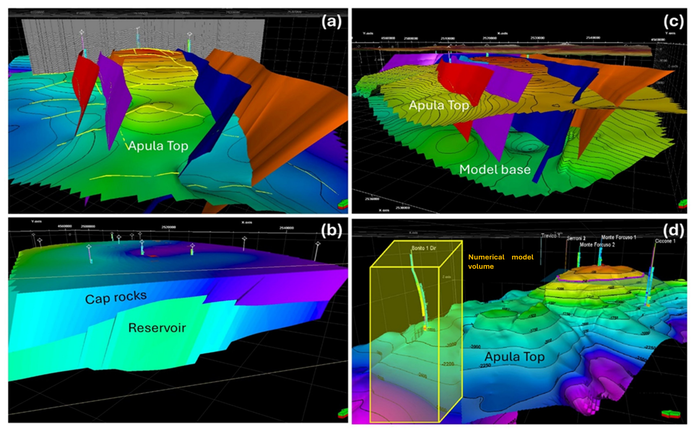


Figure 2. 3D views of: (a) time-domain model with main faults (variously colored high angle surfaces), seismic lines (yellow lines), wells, and a reflection profile (grey); (b) velocity model for time–depth conversion; (c) depth-converted geological model; (d) reservoir top with isobaths (m a.s.l.), well logs (resistivity and spontaneous potential), CO_2/water contact at Monte Forcuso 1 culmination (fuchsia polygon), and numerical model volume (yellow parallelepiped). Vertical exaggeration applied.

RESULTS

Geothermal reservoir

The 3D geological model highlights a geothermal reservoir hosted in Cretaceous–Eocene carbonates, forming a broad anticline above northeast-verging Apennine thrusts.

The reservoir is characterized by a CO_2 gas cap at its culmination and an underlying deep brackish aquifer, as well as a thermal anomaly (~125 °C at 2300 m depth), high permeability (up to 160 mD), and high porosity within fractured zones.

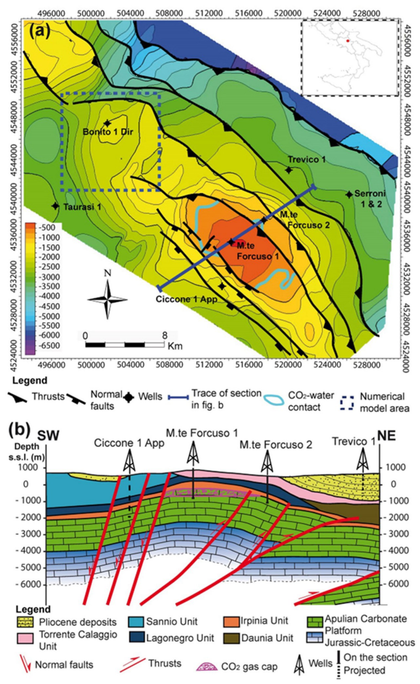


Figure 3. (a) Isobath map (m a.s.l.) of the geothermal reservoir top (i.e., top of the Apulian Carbonate Platform); (b) SW-NE geological cross-section through the geothermal reservoir. Section trace in figures 1 and 3a.

Exploitation potential

The numerical simulation indicates that a doublet system could extract heat for about 30 years. Maximum extraction rates up to 150 kg/s are possible, but to avoid early thermal breakthrough and ensure long-term sustainability, a conservative rate of 70 kg/s is recommended.

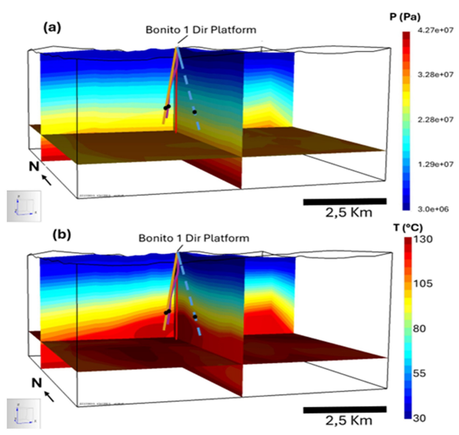
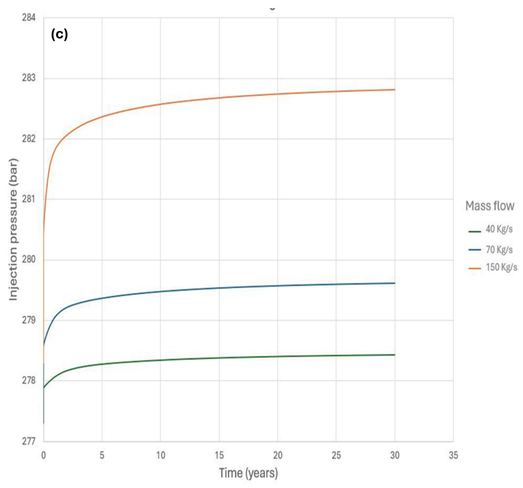


Figure 4. Pressure (a) and Temperature (b) distribution within the numerical model volume. The trajectories of the Bonito 1 Dir well (fuchsia line) and the production (light blue line; dashed behind the section) and injection (orange line) wells are shown. (c) Exploitation trends. The graph shows the injection pressure trend over time with different mass flows. Numerical model location in figures 1, 2d and 3a.



District Heating Application and cost evaluation

A geothermal district heating system was proposed for the Grottaminarda municipality (Fig. 5). At 70 kg/s, the required pumping power (327 kW) is supported by an ORC unit of 863 kW. The probability of success, derived from the reservoir mass flow curve (Fig. 6), is 45,7%. Economic analysis confirms this as a viable scenario.

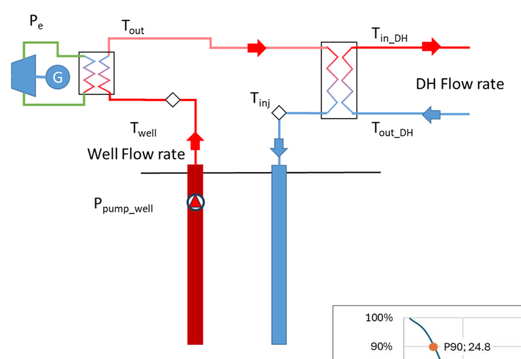


Figure 5. Exploitation scheme: District heating system integrated with an ORC unit for electricity generation.

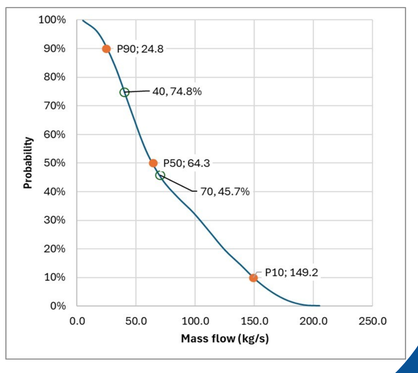


Figure 6. Probability curve of the mass flow from a doublet. In orange are reported the corresponding values P10, P50, P90. The green circles are referred to the two values of mass flow from numerical simulation.

CONCLUSIONS

In this study, the use of well data and seismic profiles, derived by past hydrocarbon exploration, enabled accurate subsurface characterization of the Guardia Lombardi area, confirming the presence of a geothermal reservoir, with fractured carbonates acting as effective reservoir rocks and overlying marly-clayey units as suitable cap rocks.

The numerical simulation identified a doublet well configuration as a viable exploitation scheme, highlighting an optimal and thermally sustainable flow rate scenarios of 70 kg/s.

A combined heat and power plant was proposed for the Grottaminarda community.

Based on the methodology developed by Alimonti et al. (2024), an ORC system with a power of 863 kW can fully cover the electrical needs for pumping and heat distribution.

This scenario shows a positive NPV of 5.2 M€, a 6.3-year payback period, and a 15% IRR.

The LCOH is 98.4 €/MWh, below the reference tariff of 100.5 €/MWh. Electricity generation significantly lowers OPEX to 0.4 M€, although CAPEX rises to 16.6 M€ due to the larger plant.

Revenues from heat and power sales make this scenario economically viable, with a 46% success probability.

This case study shows that using pre-existing O&G data can reduce geothermal exploration costs and risks, offering strong economic and environmental benefits while supporting carbon neutrality.

Acknowledgements

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For more details about this work see:
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