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# Repurposing hydrocarbon exploration data to assess geothermal potential in the southern Latium Region (Central Italy)

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## INTRODUCTION

Since the middle of the last century, many seismic reflection data have been recorded worldwide, primarily for the hydrocarbon industry. Over time some of these data have also been and are still being made publicly available, useful for research purposes. Indeed, the critical problem is that these vintage data are in analogic format and with poor quality.
In order to accurately describe the structural features of Valle Latina (**Central Italy**), we analyzed a vast hydrocarbon exploration dataset consisting of seismic reflection profiles and stratigraphic well-logs. The geophysical data comprised of public data from the ViDEPI project database and literature, as well as private data.

Our objective was to identify buried structures and the top of the carbonate platform deposits to locate potential **geothermal reservoirs**.

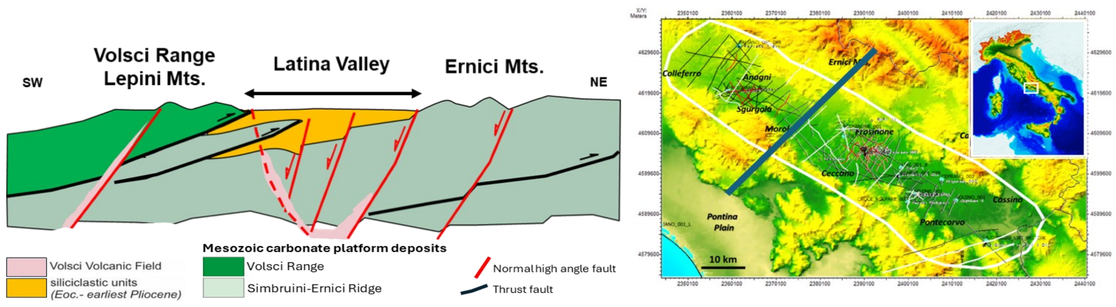



*Fig.1 Representative geological sketch (left) and subsurface dataset (right)*

## METHODS

Working within INGV SISMOLAB-3D, active since 2018, the WIGGLE2SEGY code (Sopher, 2017; Buttinelli et al., 2022) was applied to obtain high-quality digital SEG-Y files, converting raster/paper seismic data, presenting excellent detail compared to the corresponding analogic version. It removes timelines, baselines, and any horizon or fault interpretations drawn on the original analogic data. It also identifies and digitizes the signal for each seismic trace.

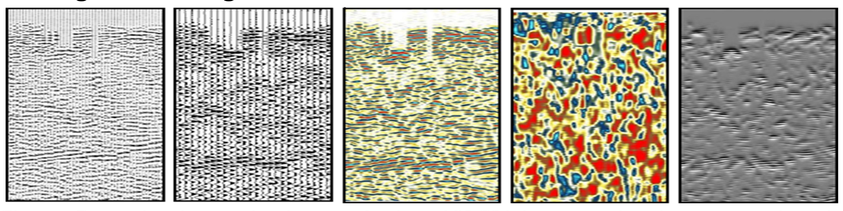


*Fig. 2a. Example of vectorization results from ViDEPI dataset using the process described in this study: Scanned image, SEG-Y file extracted from the scanned image, SEG-Y plotted with a variable density display, semblance attribute, pseudo-relief attribute*

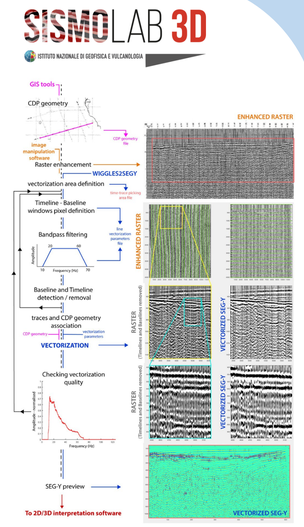



*Fig. 2b. Wiggle2segy WF (Buttinelli et al. 2022)*

The first ongoing step of the geothermal potential evaluation requires isotherm review and calculating the initial heat in place (HIP) (Muffler and Cataldi, 1978), related to the volume of the geological reservoir/structure (**Volume method**).

$$HIP = A \cdot h_{np} \cdot \rho_b \cdot c_{br} \cdot (T_i - T_s)$$

*A*: Area
*hnp* : thickness
*pb* : the density and of the bulk
*cbr* : the specific heat capacity of the bulk
*Ti* : average temperature of the reservoir
*Ts* : reference temperature equal to yearly average surface temperature

## RESULTS

### Structural interpretation and 3D reconstruction

The interpretation of the seismic lines reveals **compressive structures at the front of the Lepini Mountains**, interpreted as **splays of the main thrust**, traceable from north to south across the study area. By integrating seismic interpretation with a **velocity model calibrated to local lithologies**, it was possible to reconstruct the 3D geometry of the **top of the Lazio–Abruzzi carbonate platform deposits**, which represent the main geothermal reservoir.

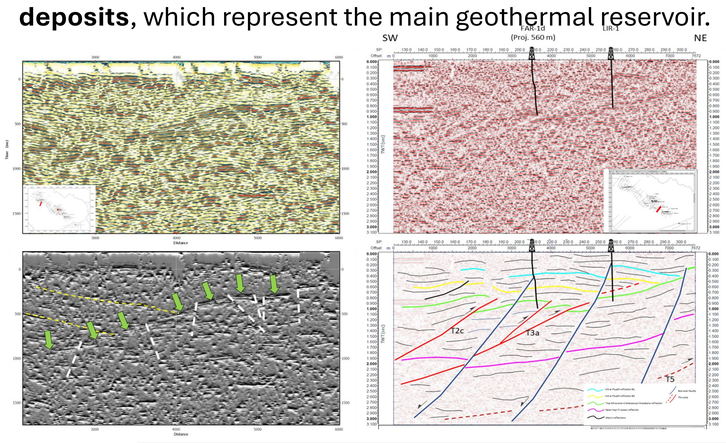



*Fig.3 Seismic interpretation on two representative dip seismic lines, after vectoralization and seismic attribute application. Green arrows highlight the top of Cretaceous platform interpretation*

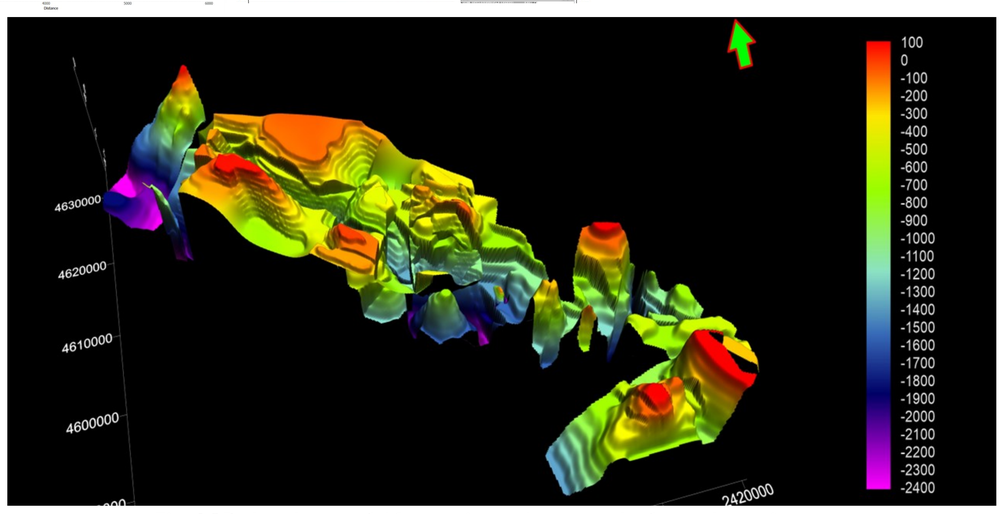



*Fig.4 3D depth top of Mesozoic carbonate platform deposits*

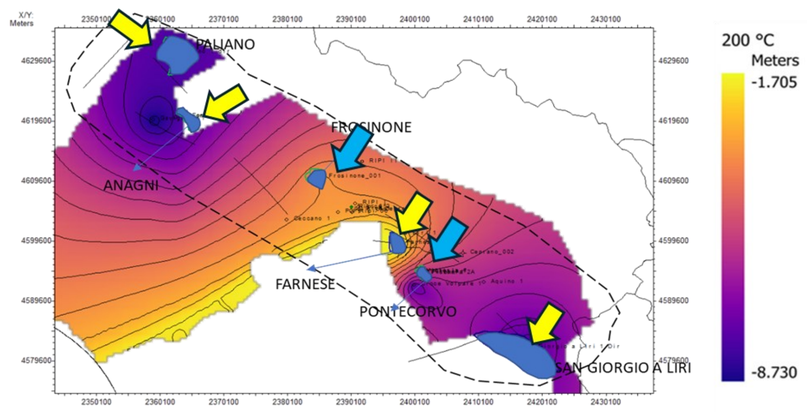



*Fig.5 Identified prospects on isotherm surface to be evaluated*

### Prospect identification

Based on structural closure, **six main prospects** were identified. Each prospect was matched with recalculated **isotherm values**, enabling a first-order evaluation of reservoir temperatures.

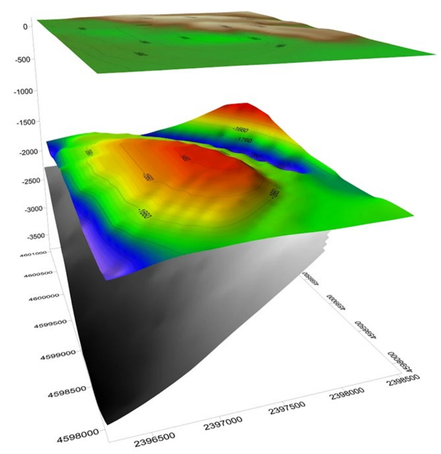


*Fig.6 3D view of Farnese structure*

### Geothermal potential assessment

Two of the six prospects (cyan arrows) exhibit temperature conditions suitable for **low-enthalpy applications**, such as greenhouse heating. The remaining four (yellow arrows) show higher temperature values compatible with **space-heating systems**. Additionally, for the **Farnese** prospect, a dedicated probabilistic analysis was performed to estimate **Heat in Place** and **Technical Potential**, providing a more robust quantification of uncertainty.

| Reservoir/Prospect Name | Depth (m) | Area (km2) | Thickness (m) | Rock Density (Kg/m3) | Porosity | Rock Specific Heat (J/Kg K) | Reservoir Temperature (°C) | Surface Temperature (°C) |
|---|---|---|---|---|---|---|---|---|
| Paliano | 667 | 23,5 | 557 | 2719 | 0,06 | 816 | 45 | 15 |
| Anagni | 600 | 6,51 | 240 | 2719 | 0,06 | 816 | 45 | 15 |
| Frosinone | 378 | 5 | 488 | 2719 | 0,06 | 816 | 36 | 15 |
| Pontecorvo | 347 | 6,48 | 278 | 2719 | 0,06 | 816 | 33 | 15 |
| S.Giorgio a Liri | 2730 | 48,25 | 1256 | 2719 | 0,06 | 816 | 66 | 15 |
| Farnese | 1724 | 4,14 | 357 | 2719 | 0,06 | 816 | **300** | 15 |

*Table 1. Parameters for HIP and TP evaluation*

| Farnese | MIN | MAX | P90 | P50 | P10 |
|---|---|---|---|---|---|
| | | | | | |
| Area | 4 | 4,5 | **4,1** | **4,3** | **4,5** |
| Thickness | 357 | 357 | **357,0** | **357,0** | **357,0** |
| Rock Density | 2350 | 2750 | **2390,0** | **2550,0** | **2710,0** |
| Porosity | 0,02 | 0,06 | **0,02** | **0,04** | **0,06** |
| Rock Specific Heat | 766 | 866 | **776,0** | **816,0** | **856,0** |
| T reservoir | 290 | 310 | **292,0** | **300,0** | **308,0** |
| T superficie | 15 | 15 | **15,0** | **15,0** | **15,0** |
| | | | | | |
| HIP (PJ) | 726 | 1180 | **771** | **953** | **1134** |
| Hr | 699 | 1140 | **743** | **919** | **1096** |
| TP (MW) | 440 | 718 | **468** | **579** | **690** |

*Table 2. Probabilistic approach for the HIP calculation*

## DISCUSSION

The selection of six prospects demonstrates how combining **structural closure** with **temperature recalculation** provides an effective strategy for ranking geothermal targets. The distinction between low-enthalpy and space-heating prospects reflects differences in depth and structural configuration, while the probabilistic analysis performed on the Farnese prospect emphasizes the importance of quantifying uncertainty in early exploration stages.

Overall, the compressive structural style—with multiple thrusts and secondary splays—may locally influence permeability and hydraulic connectivity within the Cretaceous–Miocene carbonate reservoir. This highlights the need for additional data and refined thermal and structural modeling to better constrain the geothermal potential of the area.

*Table 3. HIP and TP evaluation*

| Reservoir/Prospect Name | HIP (PJ) | Hr (PJ) | Tp (MW) |
|---|---|---|---|
| Paliano | 917 | 612 | 57,6 |
| Anagni | 110 | 73 | 6,9 |
| Frosinone | 120 | 63 | 4,2 |
| Pontecorvo | 76 | 34 | 1,9 |
| S.Giorgio a Liri | 7221 | 3681 | 569,7 |
| Farnese | 984 | 898 | 565,4 |

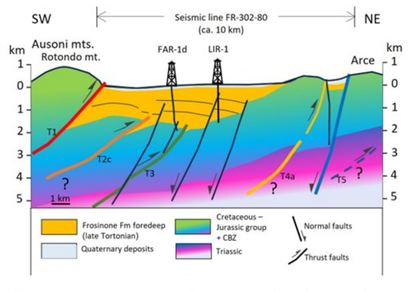



*Fig. 7 Interpreted geological section*

## CONCLUSION

The combined seismic reinterpretation and velocity-model integration enabled a consistent reconstruction of the structural framework despite the complexity associated with **compressive splays along the Lepini thrust front**, improving the definition of the carbonate reservoir geometry. This approach led to the identification of six geothermal prospects with differentiated thermal characteristics, revealing a **distributed and versatile geothermal potential**, ranging from low-enthalpy applications to space-heating systems.

The probabilistic analysis performed on the Farnese prospect demonstrates the value of incorporating quantitative uncertainty assessment from the early exploration stages, strengthening the prioritization of potential targets. Overall, the study confirms the effectiveness of leveraging vintage data and 3D structural modeling to establish a preliminary understanding of geothermal potential and guide subsequent investigation phases.

## REFERENCES

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