LOW ENTHALPY GEOTHERMAL RESERVOIR EXPLORATION IN THE APENNINES BURIED THRUST FRONT SOUTH OF PARMA

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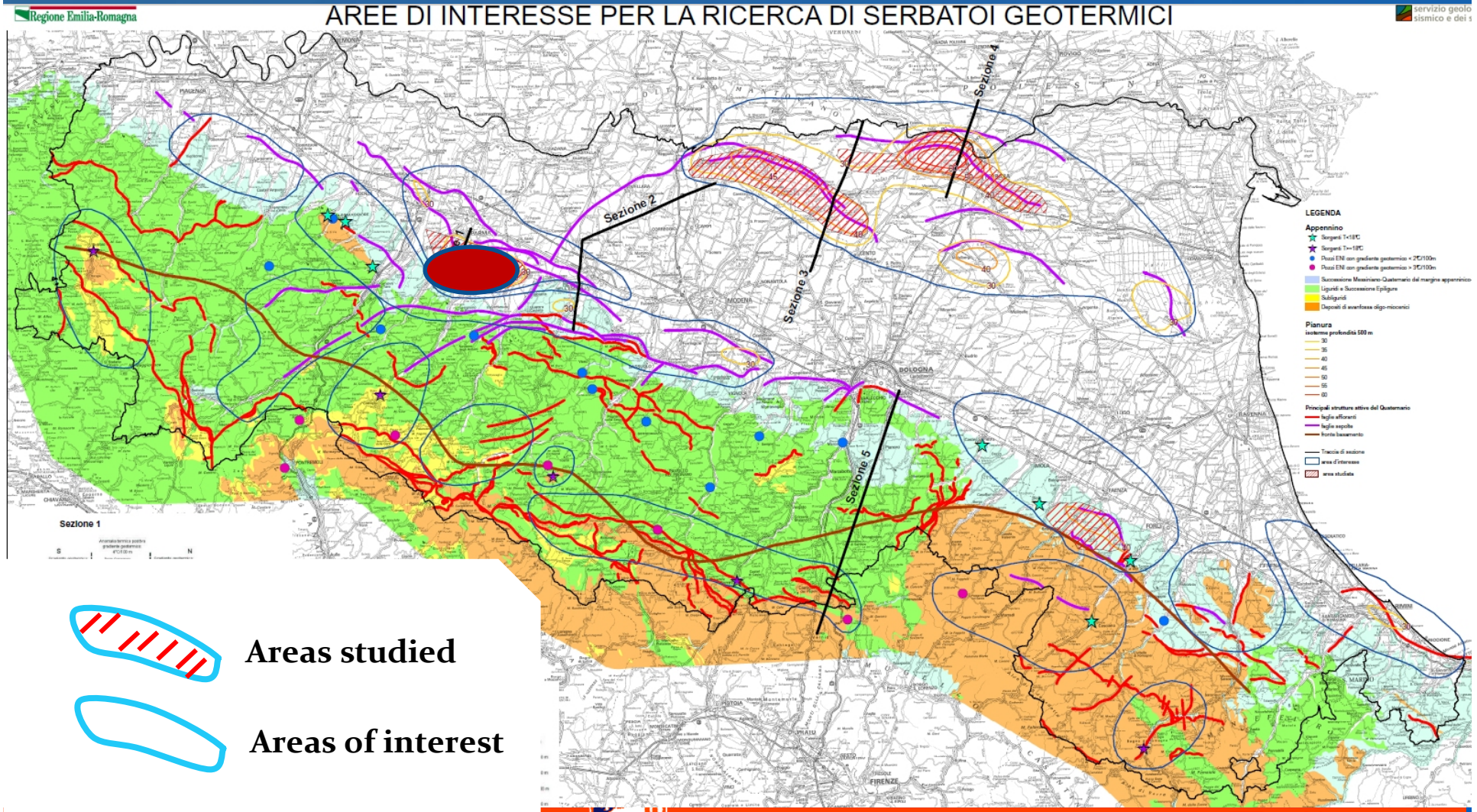
GOAL OF THE WORK

Stratigraphic and structural reconstruction of the deep subsurface in the south sector of Parma city for characterizing low enthalpy (<90°C) geothermal potential.

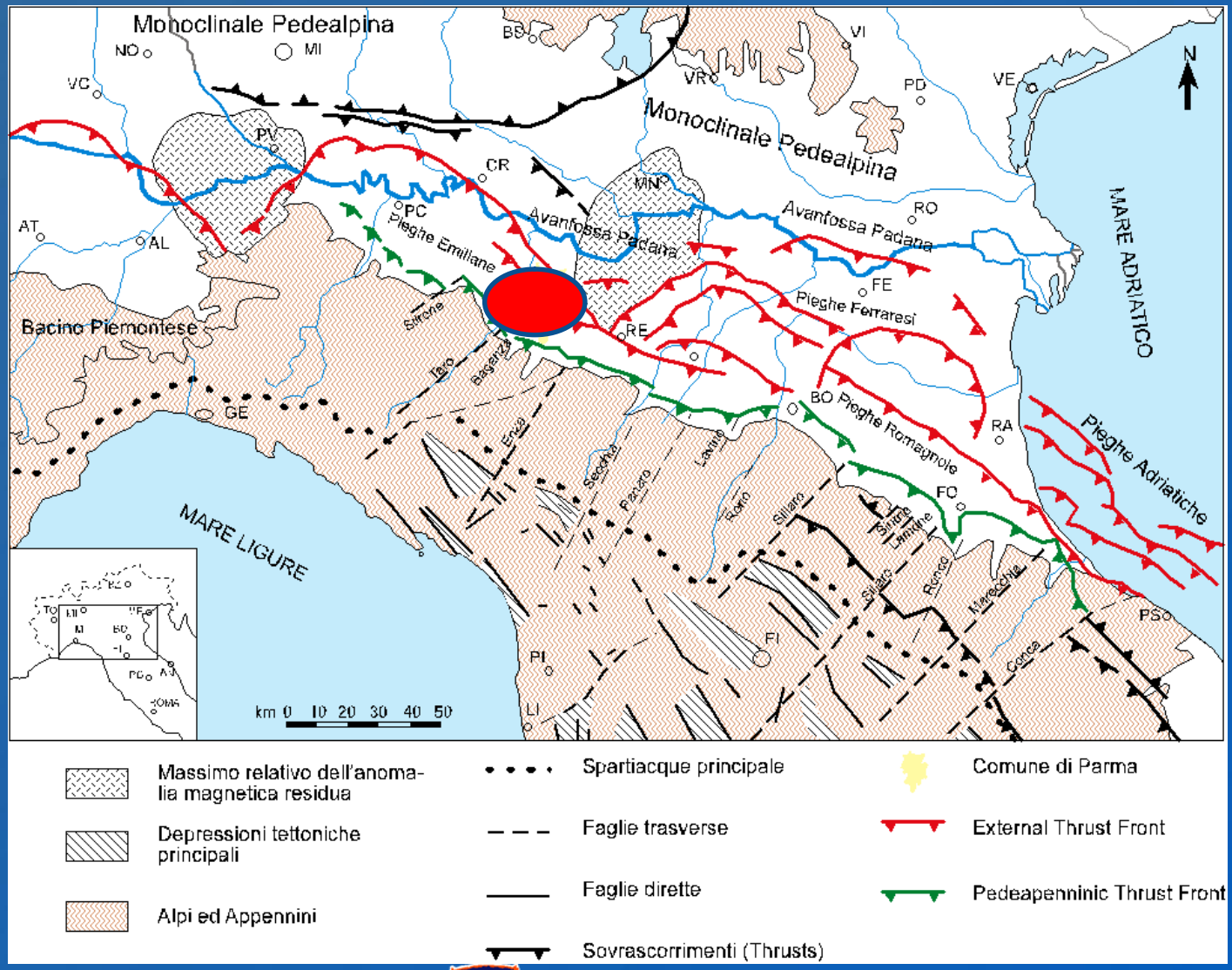
The SGSS has produced a map of areas of interest to search low enthalpy geothermal reservoir.

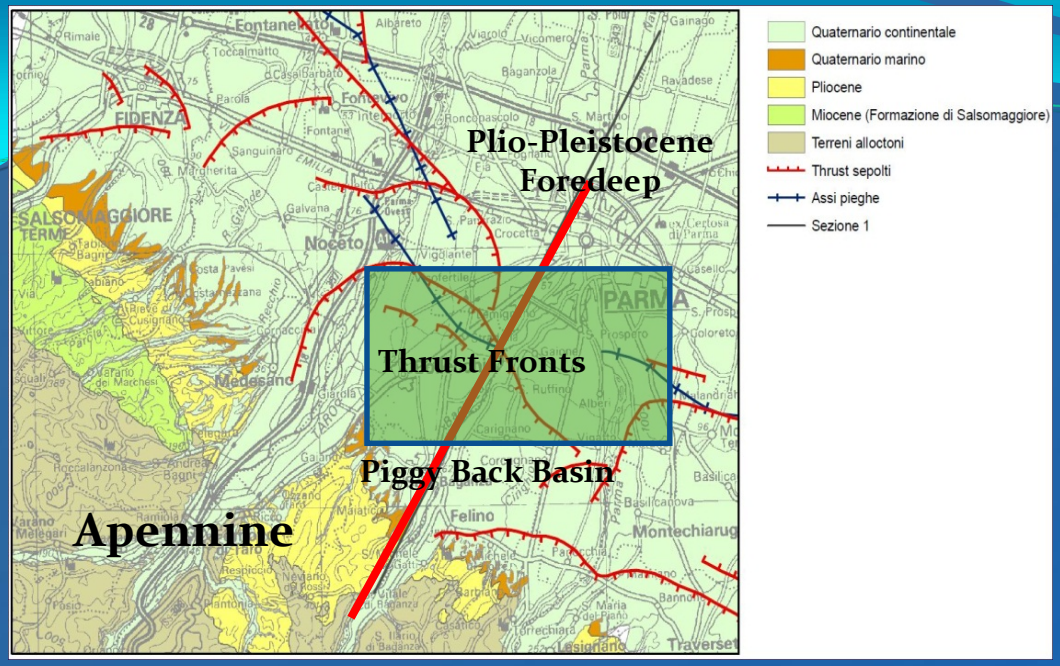
The areas of interest, including the area of this work, are located in correspondence of buried structural high



The study area lies on the southern edge of the Padan Sedimentary Basin charctherized by strong structural deformation in the upper Miocene to Pleisotcene that created overlapping arcs (thrust fronts)

From AGIP, 1983





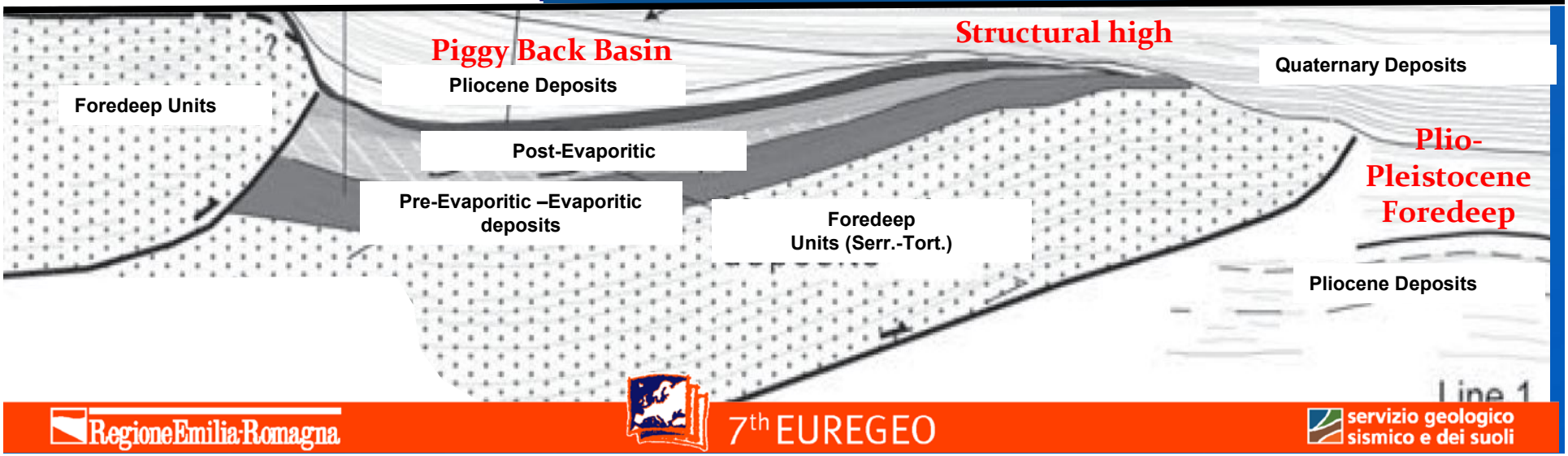
SCHEMATIC GEOLOGICAL SECTION OF THE STUDY AREA

In the schematic geological section below we can see the main thrust front in the study area with the presence of the foredeep serravallian and tortonian deposits (turbidite sandstone and marl) and the actual Plio-Pleistocene foredeep basin toward north.

South

STUDY AREA

North



DATA BASE

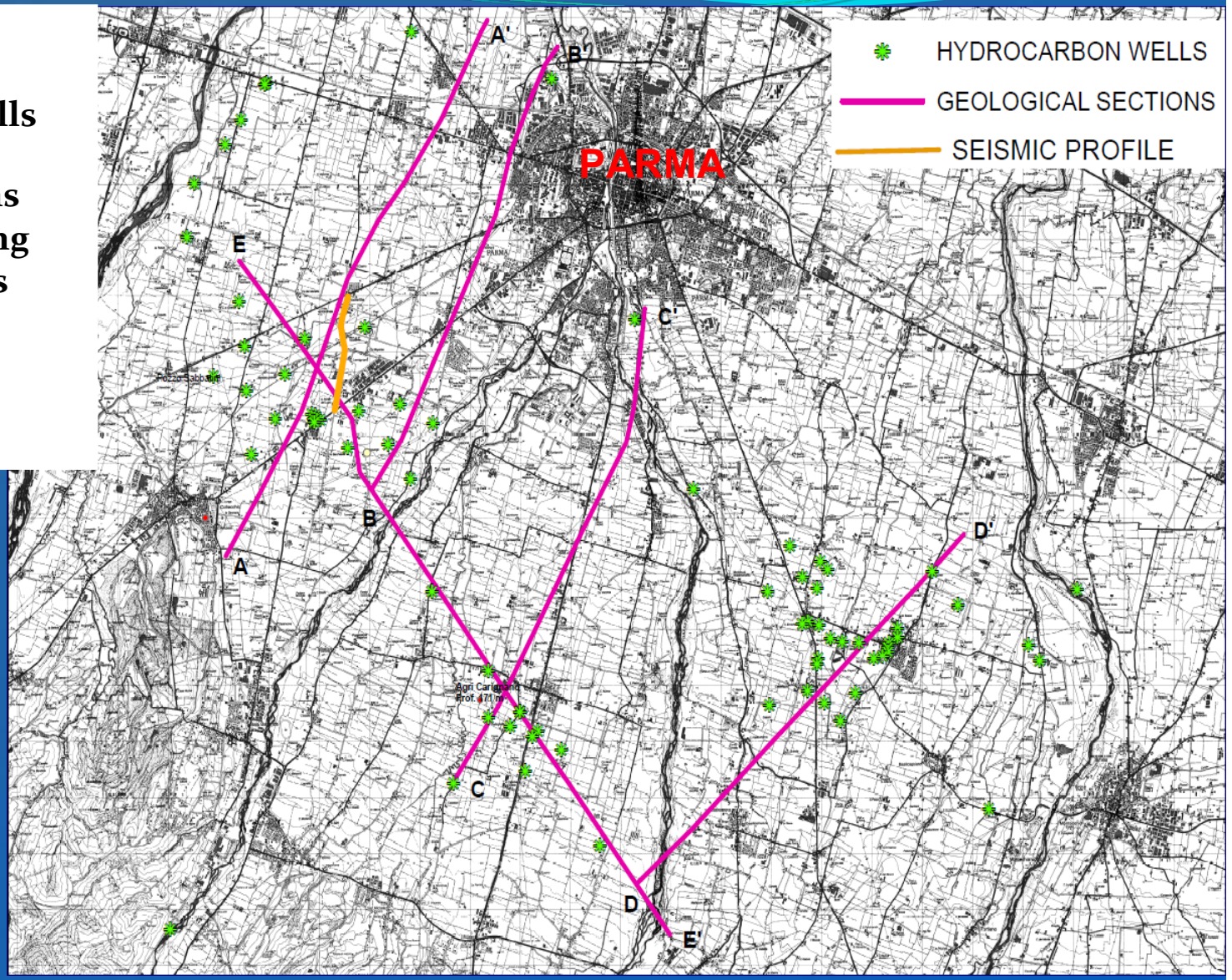
- Profiles of ENI – AGIP hydrocarbon wells.
- Thermometric data taken from UNMIG Database and from SGSS Database
- Consultation of ENI – AGIP seismic reflection profiles
- Thermometric measurements in water wells
- Reflection seismic survey carried out specifically in the study area

LOCATION OF DATA IN THE STUDY AREA

18 Hydrocarbon Wells

5 Geological sections drawn by interpreting the seismic profiles

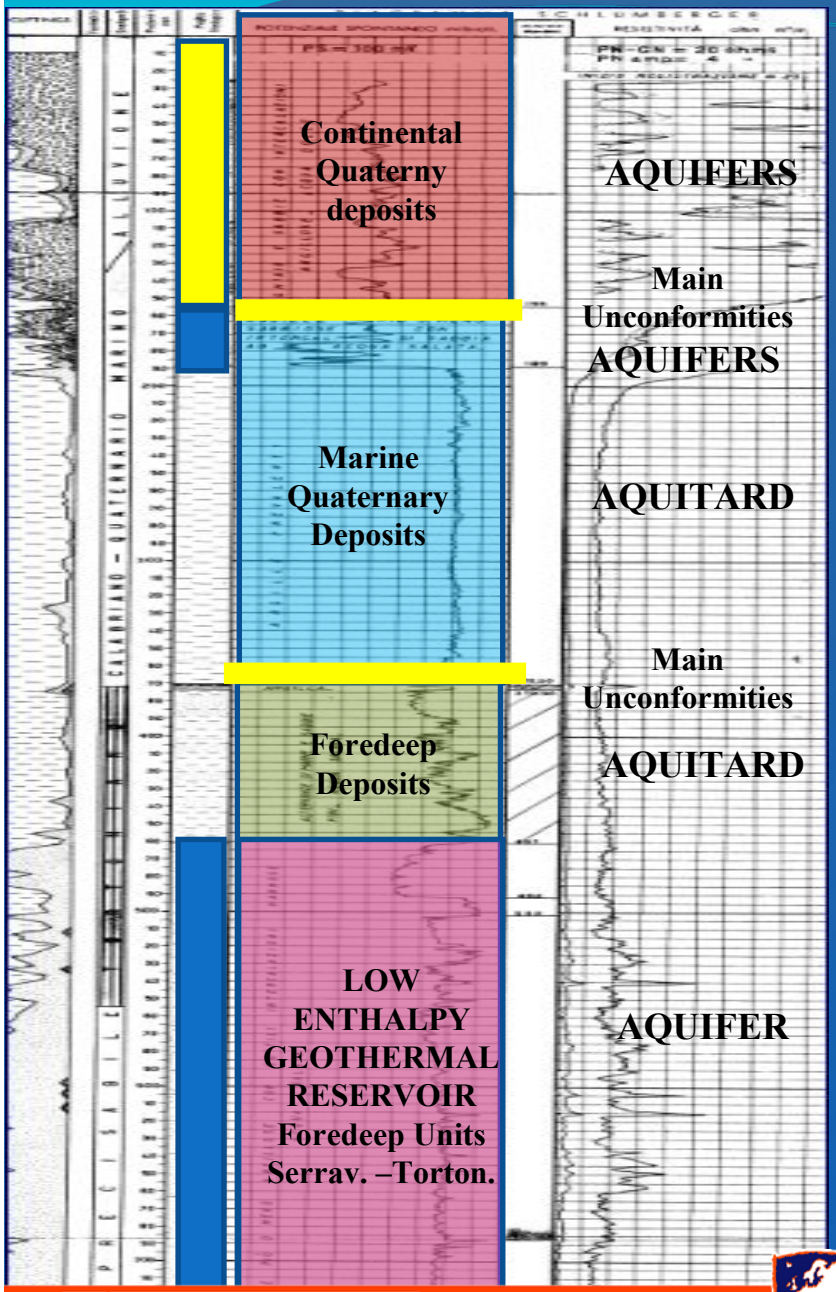
1 High resolution seismic reflection profile



DATA ANALYSIS

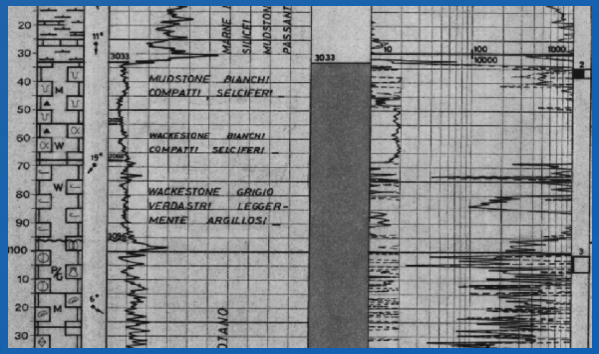
ANALYSIS OF WELLS LOG PROFILE

«COLLECCHIO 3» WELL



The wells data allow a preliminary assessment of hydrogeological and thermal properties of deep aquifer (geothermal reservoir) and contain the main stratigraphic data

Total porosity by electric log



Hydraulic head by density of perforation mud

FANGO DI PERFORAZIONE

Tipo AR:

m	0 ÷ 56	D.	1060
"	56 – 350	D.	1120

Tipo LS:

m	350 – 406	D.	1270
"	406 – 813	D.	1420
"	813 – 856	D.	1790
"	856 – 934	D.	1870
"	934 – 2659	D.	1900
"	2659 – 2876	D.	1870
"	2876 – 2972	D.	1070
"	2972 – 3956	D.	1100
"	2956 – 4160	D.	1200
"	4160 – 4249	D.	1220
"	4249 – 4271	D.	1270
"	4271 – 4304	D.	1300
"	4304 – 4386	D.	1380
"	4386 – 4493	D.	1420
"	4493 – 4578	D.	1450
"	4578 – 4619	D.	1500
"	4619 – 4685	D.	1550
"	4685 – 4740	D.	1650
"	4740 – 4748	D.	1690
"	4748 – 5000	D.	1740

Temperature by electric log

TEMPERATURE DAI LOGS ELETTRICI

A m 347 = 40,5°C.

A m 807 = 56°C. Statica (calcolata) = 58°C.

A m 2878 = 68,8°C. Statica (calcolata)=71,7°C

A m 3971 = 79,4°C. Statica (calcolata) = 83°C

A m 4390 = 88,3°C. Statica (calcolata) = 89,6°C

A m 4723 = 93°C. Statica (calcolata) = 103°C.

ANALYSIS OF BIBLIOGRAPHIC DATA

ENI – AGIP wells drilled in the study area domostrated the salt water saturation of these arenitic bodies

In the foredeep Serravallian – Tortonian turbidite deposits we can find arenitic body with porosity and hydraulic conductivity between 0,080 e i 0,220 Darcy likely to be considered potential geothermal reservoir (2,1 $*10^{-4}$ cm/sec) (GE.T.AS. s.r.l., 1988). The hydraulic parameters were calculates through the interpretation of hydrogeological tests in hydrocarbon wells

In conclusion bybliographic data confirm the hydrogeological potential of the tortonian turbidite aquifer system in the study area

ANALISYS OF TEMPERATURE DATA

The temperature data taken from ENI-AGIP wells and referred to as «calculated measures» have been used as a matter of course, while those listed as «unregulated» are just taken as a reference.

From the measurements of the heat flow and the calculated temperature in the ENI-AGP wells we tried to extrapolate the temperature values every 50 meters of depth within the Serrravallina-Tortonian succession through the law that describes the conduction of heat (D.Halliday, R. Resnick, J. Walker, 2002):

$$P_c = \frac{Q}{t} = k A \frac{T_1 - T_2}{L}$$

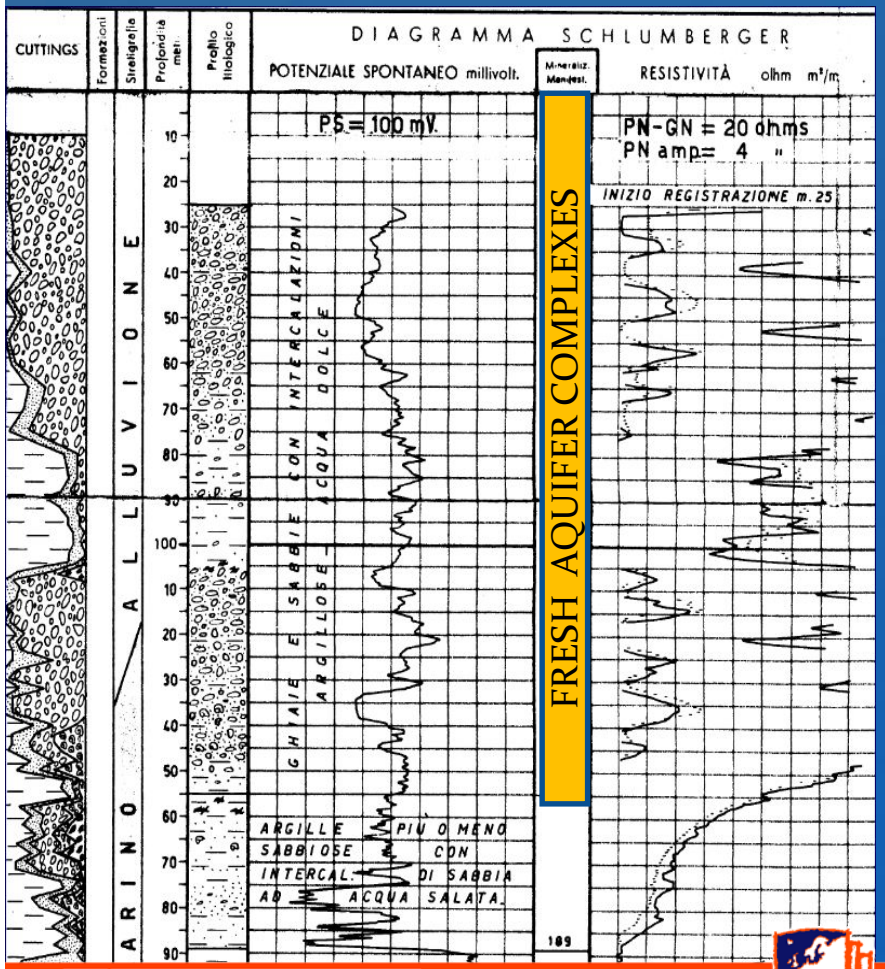
Within the miocene foredeep succession was then calculated the geothermal gradient using the formula

$$i = \Delta T / \Delta x$$

THERMAL PROFILE IN WATER WELL

In this work, in addition to the literature search of temperature/heat data, have been carried out measurements of temperature in water wells located in structural high areas in order to obtain thermal profiles in quaternary continental succession seat of the main fresh water aquifer complexes..

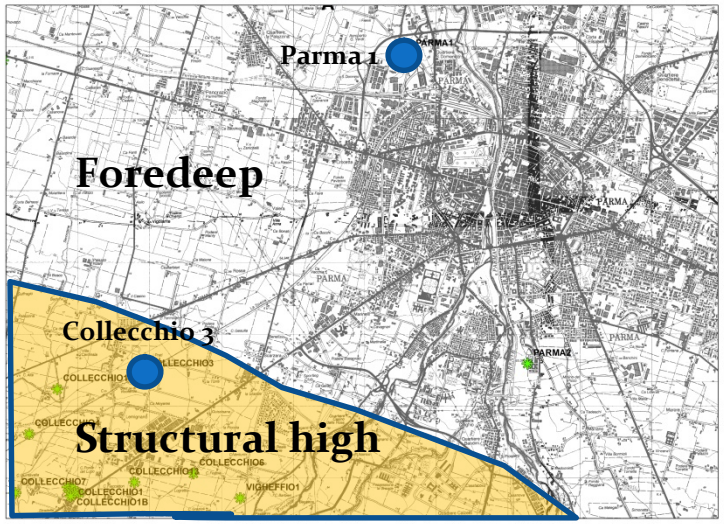
Collecchio 3



Example of thermal profile in water well located near the AGIP well «Collecchio 3»

DEPTH	TEMPERATURE
20 m	14,4°C
40 m	14,2°C
60 m	14,3°C
80 m	14,4°C
100 m	15,6°C
120 m	16,0°C
140 m	16,1°C
160 m	16,18°C
170 m	16,25°C

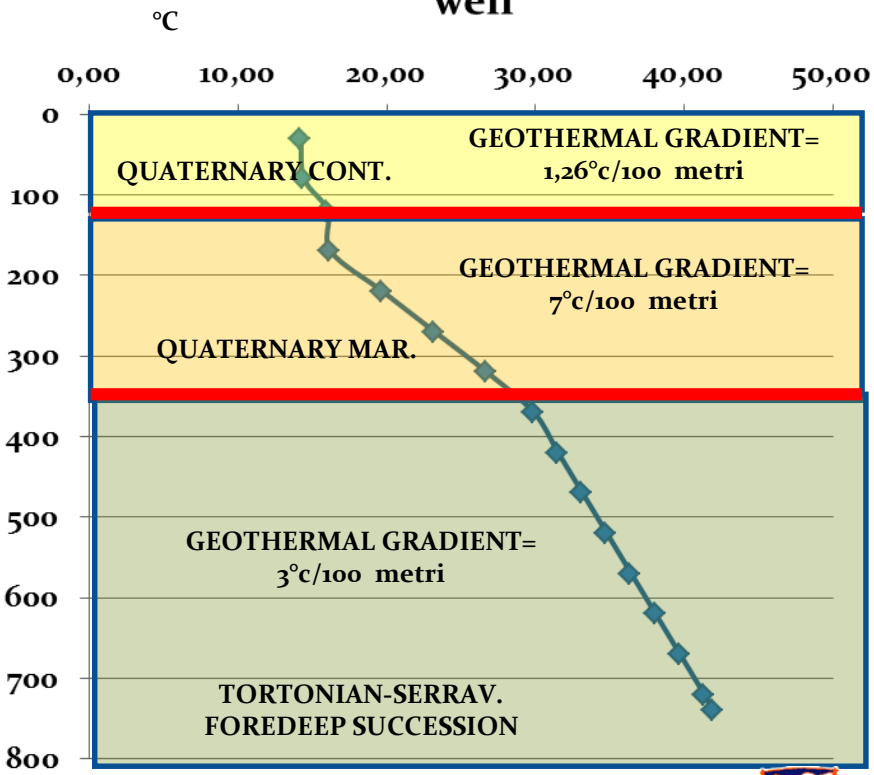
GEOTERMAL GRADIENT
1,26°c/100 meters



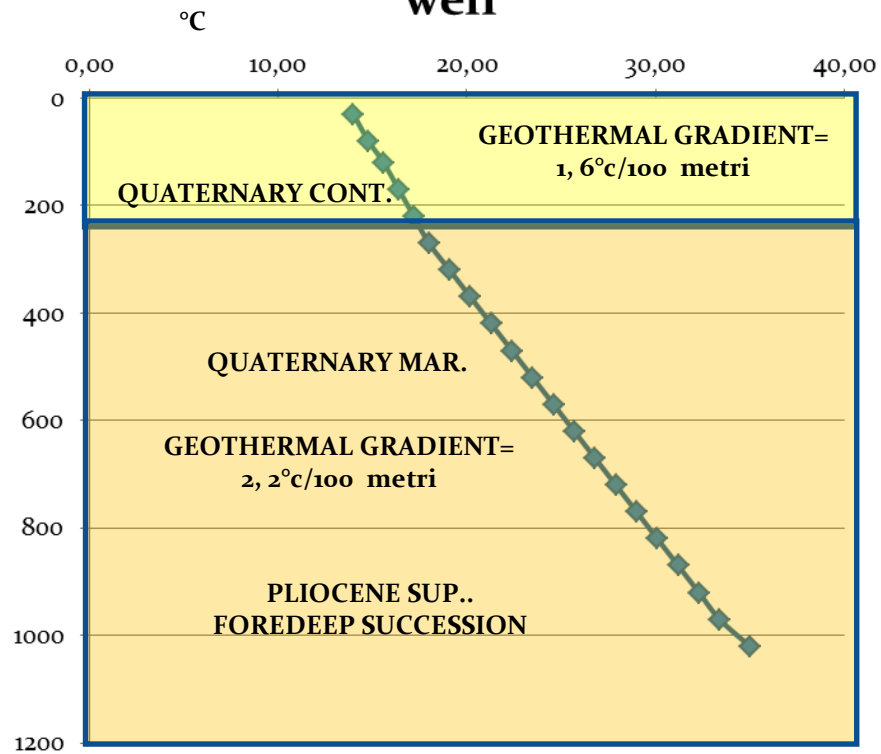
In structural high areas the temperature data in shallow water wells have been extrapolated in depth with those of deep hydrocarbon wells.

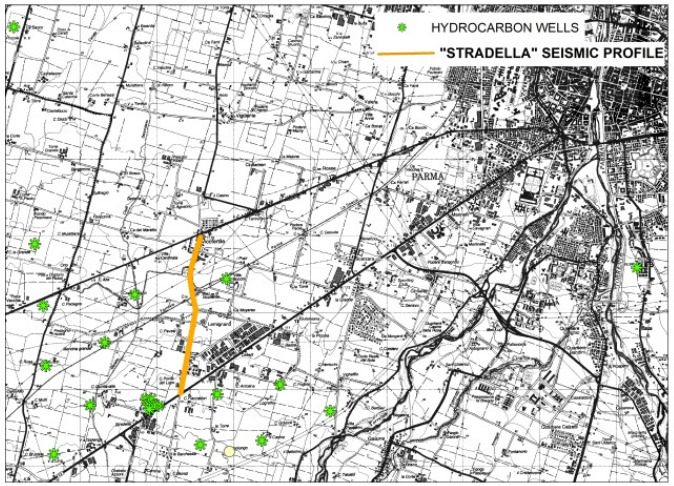
In the graphics below are compared the geothermal gradient of structural high with those of actual foredeep basin

Thermal Profile of "Collecchio 3" well



Thermal Profile of "Parma 1" well



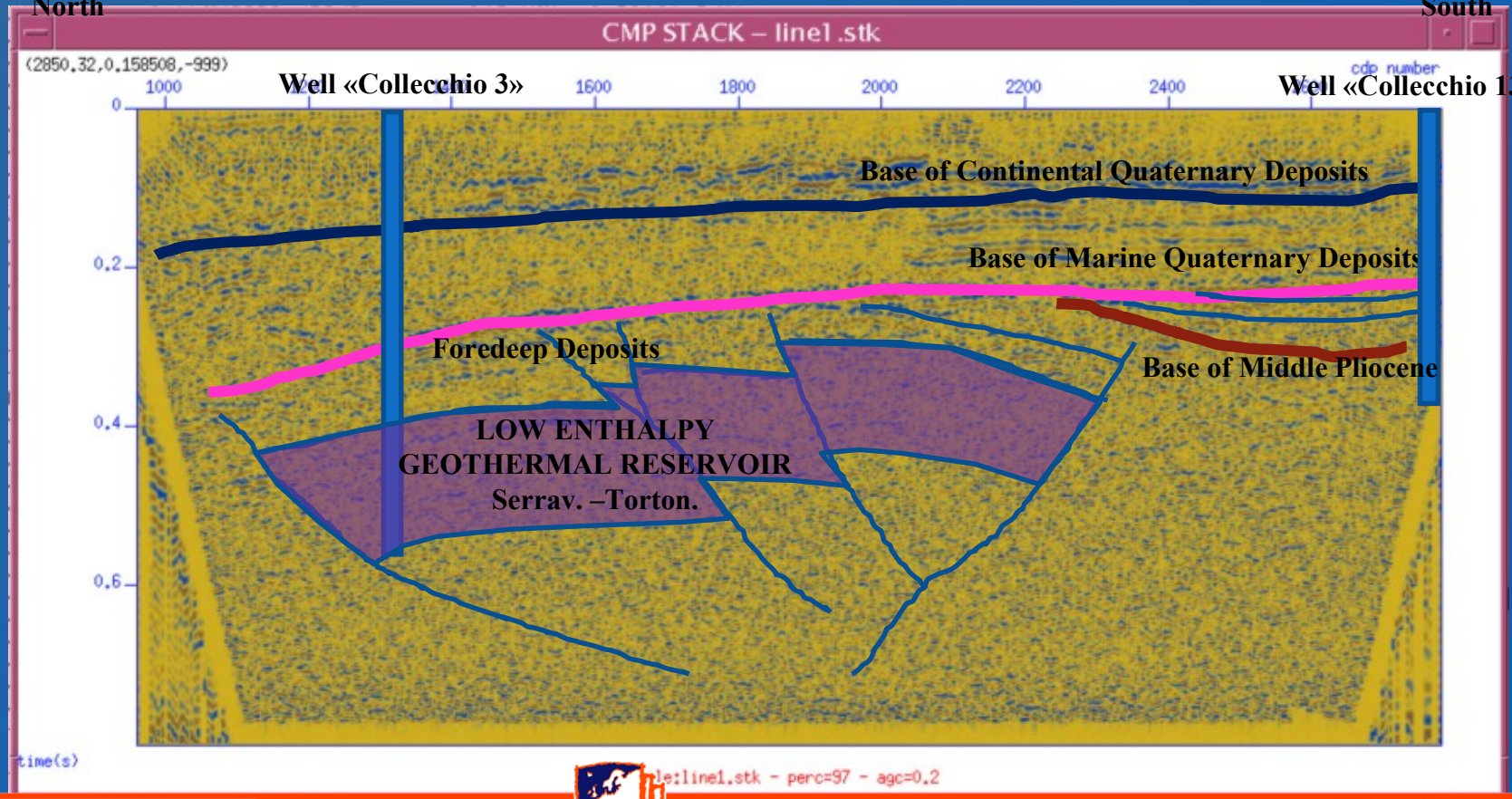


INTERPRETATION OF SEISMIC PROFILE
The example of «STRADELLA» profile

The seismic refelction profile allow detailed stratigraphic and structural analysis of subsurface.
Reflectors of seismic profile were calibrated using the hydrocarbon wells Collecchio 3 and Collecchio 13

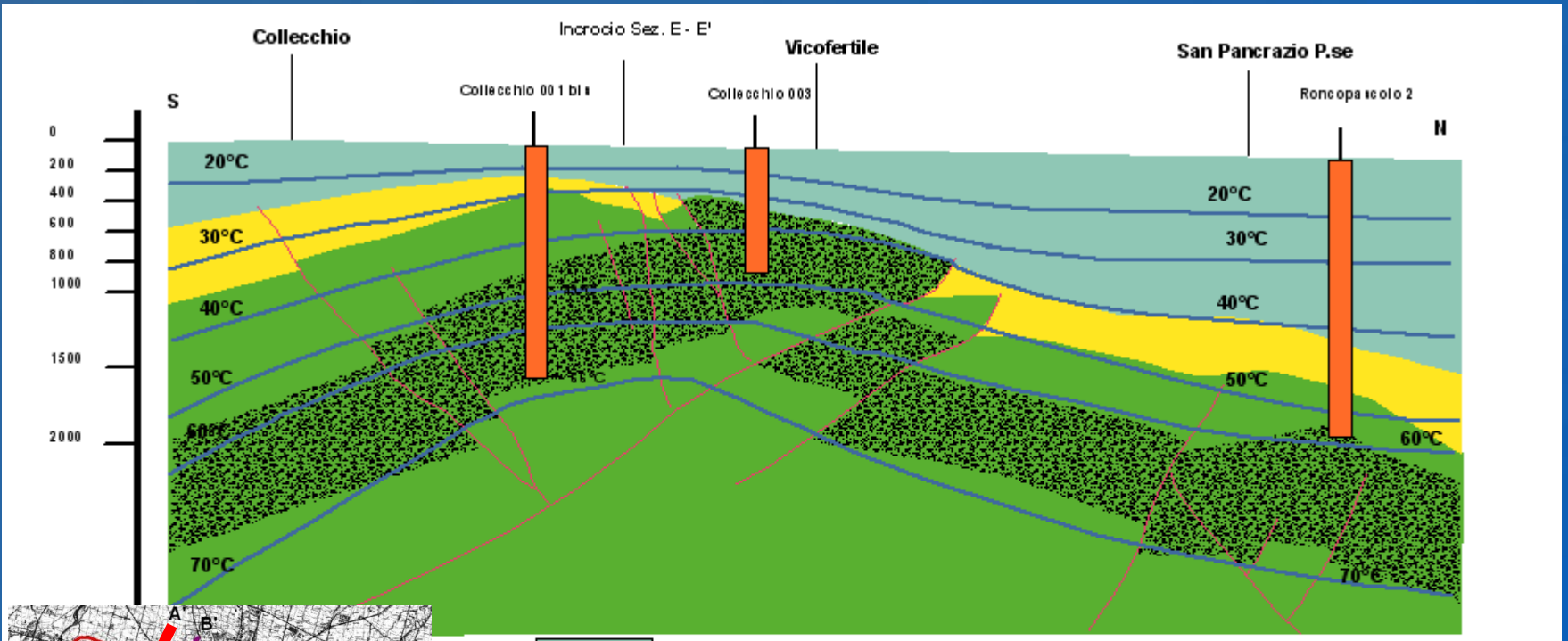
North

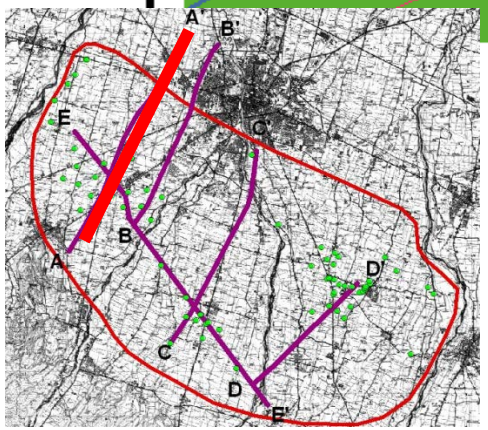
South



EXAMPLE OF CARTOGRAPHIC MAPPING

For the realization of geological/geothermal section and cartographic mapping have used the interpretations of the database shown in previous slides





Quaternario (dall'attuale a 2,6 M.a.)

Pliocene (da 2,6 M.a. a 5,3 M.a.)

Miocene (da 5,3 M.a. a 23,0 M.a.)

Sistema Acquifero Tortoniano

Isoterme (intervallo 10° C)

Fratture principali

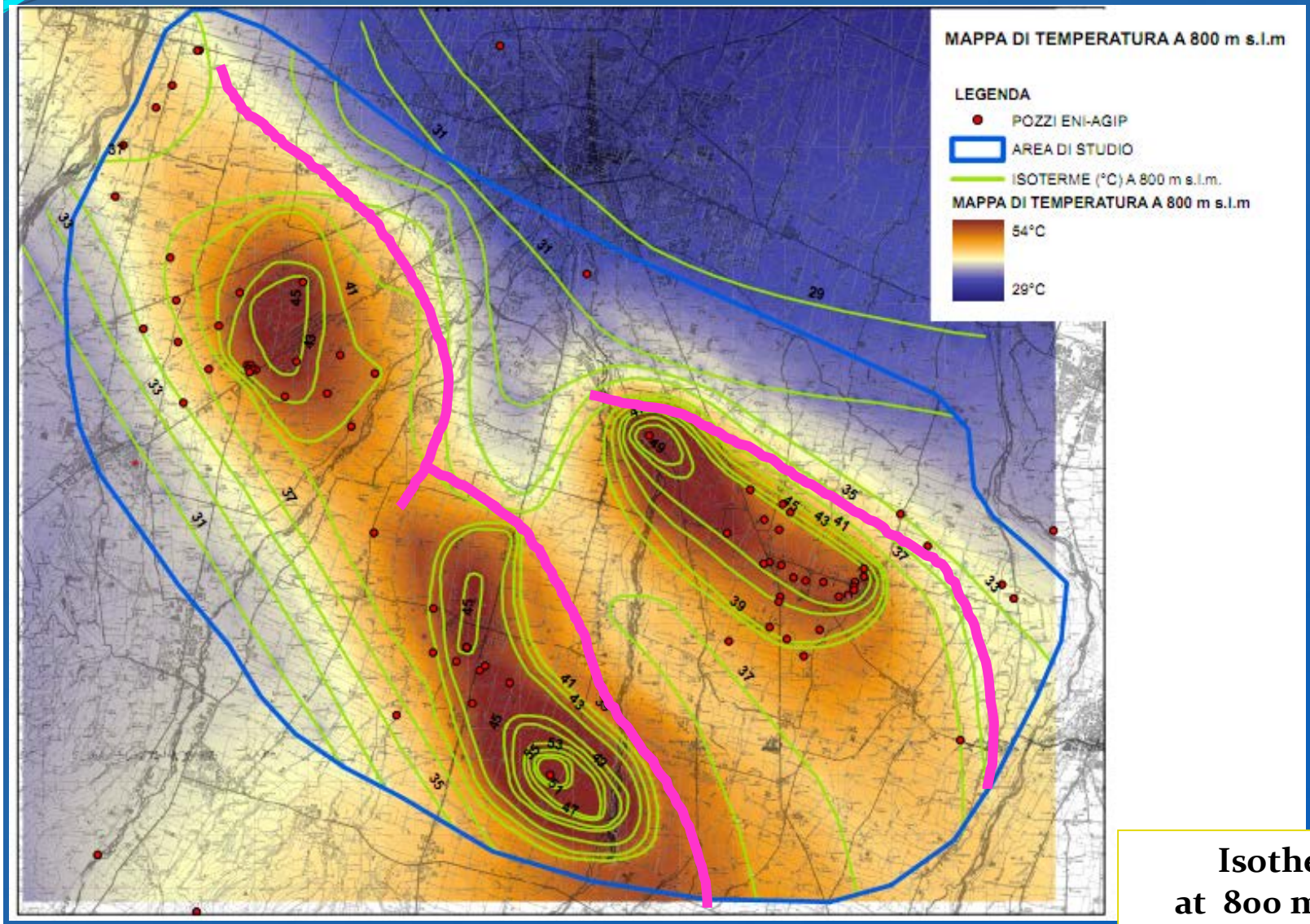
Pozzi ENI - AGIP

This slide shows a geological section that is processed highlighting the isoterm path and the tortonian aquifer system

Geological Section Collecchio – San Pancrazio

Using data extrapolated from geothermal sections and geothermal wells has estabilished a map of temperature at 800 meters depth.

Using geostatistical methods, in particular Kriging, has analyzed the spatial distribution of z points to obtain bathymetric grid of isotherms



There is a close correlation between the presence of geothermal anomalies and thrust fronts

Isotherms Grid at 800 meters depth

CONCLUSION

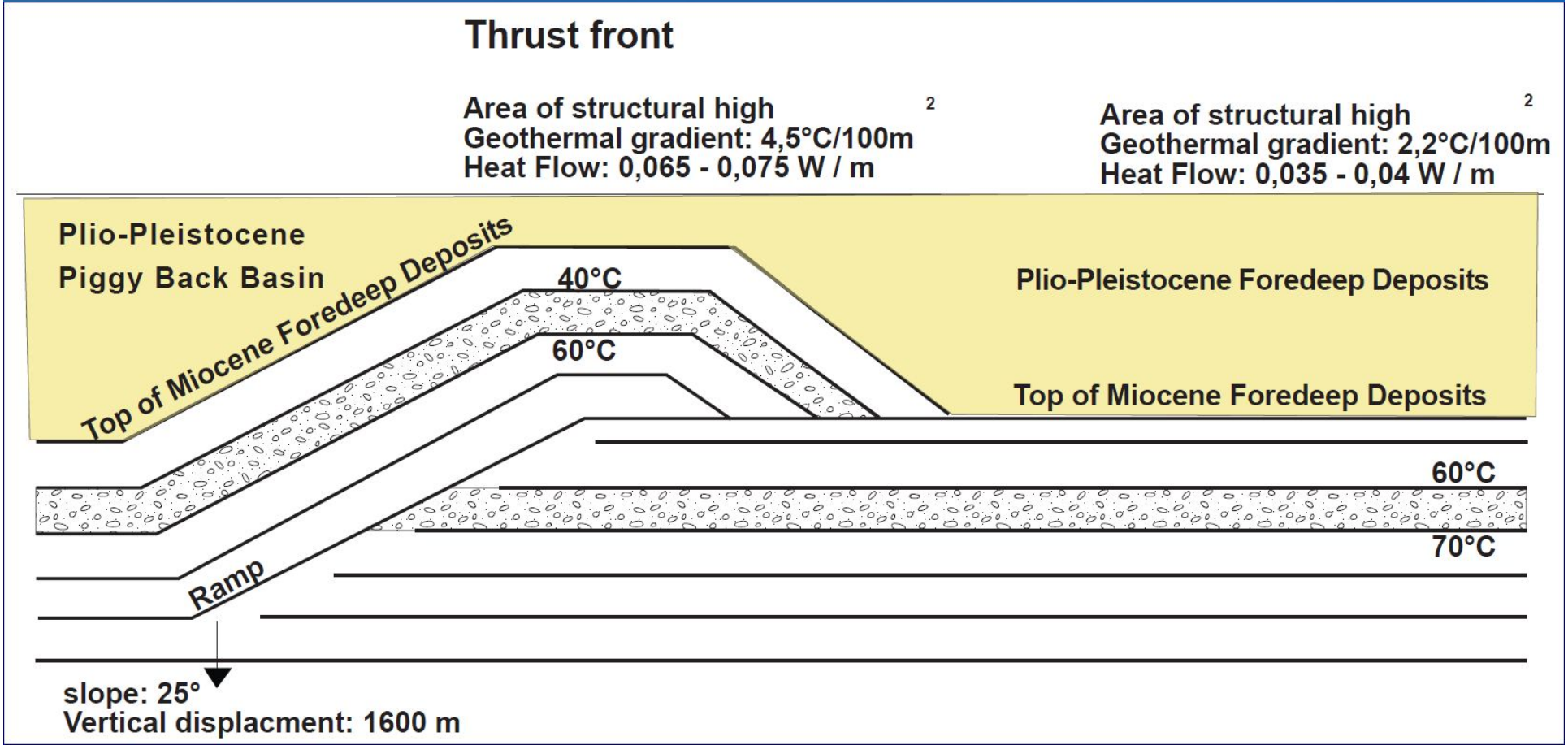
PALEOTHERMIC MODEL IN THE STUDY AREA

The deduced paleotermic model shows that in the areas of structural high the main positive thermal anomalies develop within 1000-1500 meters depth.

The positive thermal anomalies results in correlation with the presence of thrust fronts and the extent of vertical displacement of Miocene sedimentary succession

The geothermal gradient is about twice that of actual foredeep sector: 4°-4,5°C / 100 m against 2,2°-2,4°C / 100 m

The heat flow in structural high is about 0,065 – 0,075 W / m^2 compared to about 0,030-0,035 W / m^2 in actual foredeep

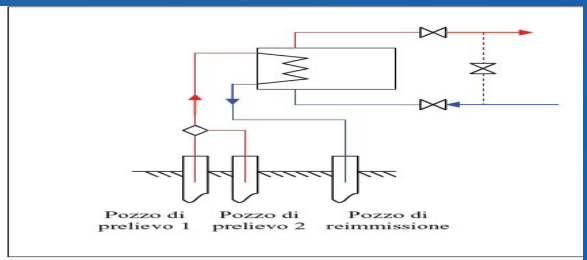


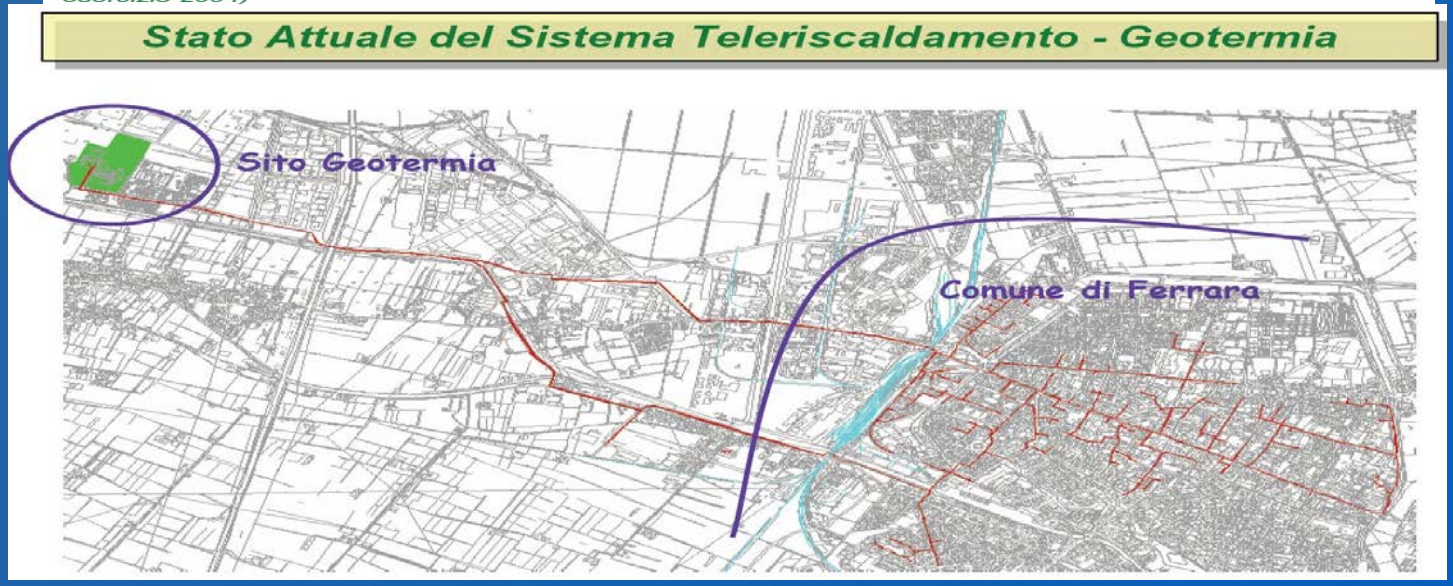
CONCLUSION

Further characterization of the miocene geothermal reservoir could be used to pre-feasibility studies on the use of low enthalpy geothermal reservoirs in the urban area of Parma by open loop system (doublet wells). We recall how in Emilia-Romagna Region the low enthalpy is already used for years for district heating in the city of Ferrara.

Dati di riferimento attuali:

Portata complessiva 400 m3/h
Temperatura fluido geotermico 100-105 °C
Temperatura fluido TLR in mandata 90-95 °C
Temperatura fluido TLR in ritorno 60-65 °C
Potenza termica nominale 14 MWt
Disponibilità di utilizzazione continua
Energia termica fornita 80 GWht/anno (Dato esercizio 2004)





This study further confirm the fact that the SGSS can make new insights and research in structural high areas aiming their geothermal characterization

Thanks for your attention