LOW-ENTHALPHY GEOTHERMAL RESERVOIRS EXPLORATION IN THE APENNINES BURIED THRUST FRONT SOUTH OF PARMA (ITALY)

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INTRODUCTION

In the southern Po River basin there is no high-enthalpy geothermal source known at economically convenient depths. Yet, the growing green economy stimulates scientific research in the field of geothermal energy, which is becoming more and more competitive even at low-temperatures (>40°C). The screening of the Emilia-Romagna alluvial plain for potential geothermal resources completed by the Regional Geological Survey led to the recognition of several areas with positive thermic anomalies.
The geographic distribution of thermic anomalies coincides with the position of the main buried tectonic structures. In the southern margin of the Po River alluvial plain these structures are represented by a system of faulted folds named Emilian Folds by Pieri & Groppi (1981). The Emilian Folds represent thrust fronts whose crest may be encountered at a few tens of meters depth below ground surface, as in the case of the alluvial plain south of Parma which is the object of the authors ongoing studies. The positive thermic anomalies detected in the area encouraged this research aimed at finding potential geothermal reservoirs.

FIELD DATA

The southern margin of the Po River plain represents the perisutural zone of the Apennines orogenic belt in which Neogene and Quaternary sedimentation has been controlled by thrust tectonics (Fig. 1). The positive structure, extending south of Parma on the alignment of the towns of Monticelli Terme, Vigatto, Collecchio and Madregolo, consists of a thrust generated antiform deforming Miocene-Pleistocene beds.
At Monticelli Terme the alluvial deposits are directly superposed on the eroded Miocene substrate and are only 10 m thick. Westwards the thickness of the alluvium, modulated by the culminations and depressions of the positive structure, gradually increases and its erosive base overlies the marine *Costamezzana* synthem (Calda et al, 2007).

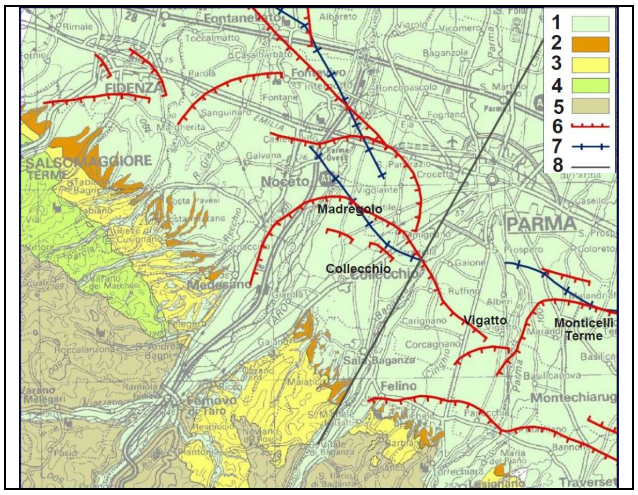

Figure 1 - The buried thrusts deforming Miocene-Pleistocene beds in the perisutural front of the Apennines south of Parma. 1.Quaternary continental deposits, 2. Quaternary marine deposits, 3. Pliocene, 4. Miocene, 5. Allochtonous, 6. Buried thrusts, 7. Fold axes of positive structures, 8. Trace of section in figure 2.

The Pliocene-Quaternary sedimentation, controlled by eustatic sea-level fluctuations, has been interpreted on the basis of regional unconformity surfaces (RER & ENI-AGIP, 1998) in: alluvial sedimentary synthems (Qc_2 and Qc_1 of Late-Middle Pleistocene age) and marine sedimentary synthems (*Costamezzana* and *Stirone* of Early Pleistocene - Late Pliocene age and *Lugagnano* and *Vernasca* of Middle - Lower Pliocene age).
The Emilian Folds have been extensively investigated as potential oil and gas reservoirs with the production of a rich wealth of data, in particular, seismic profiles, stratigraphic wells, and numerous well-log data. Additional information, with precise depth-temperature profiles, is provided by the so-called UNMIG collection and the ENEL-CNR studies on geothermal resources. The implementation of these data with the stratigraphic databases of the University of Parma and the Regional Geological Survey allowed the

construction of key geologic cross-sections and their dressing with the temperature changes at depth (Fig. 2).

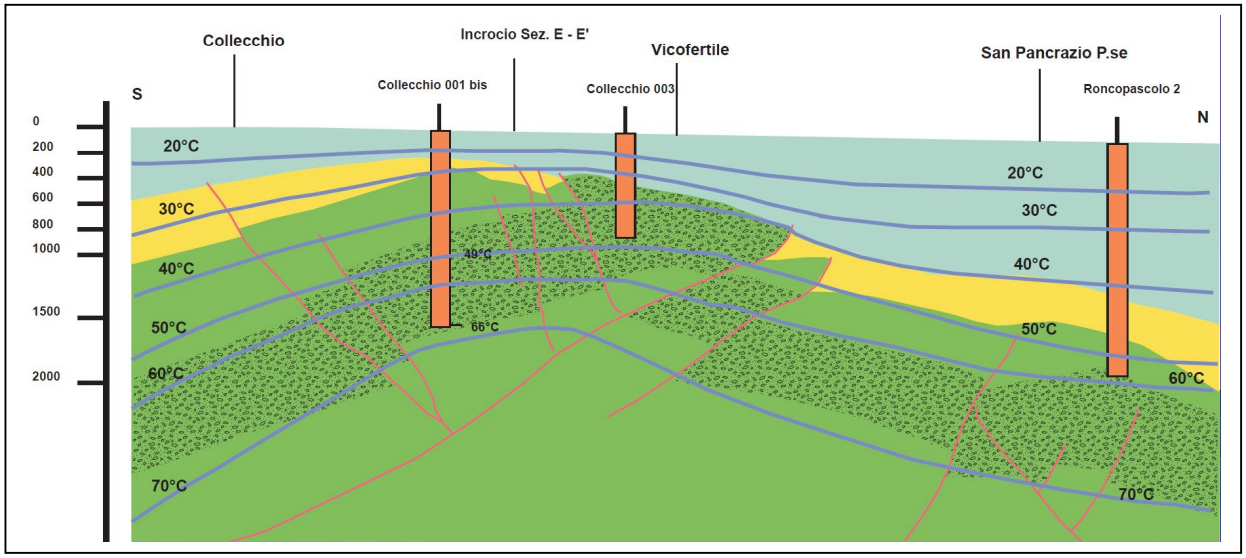

Figure 2 - Section of the Collecchio positive structure (trace in figure 1). Light blue: Quaternary marine and alluvial deposits, yellow: Pliocene, green: Miocene, shingled: saturated turbidite sandstone.The isotherms pattern and related thermal anomaly are controlled by the closely-spaced faults affecting the thrust crest zone down to 1500m of depth.

GEOTHERMAL RESERVOIRS

In the study area the geothermal reservoir has been recognized in the turbidite Miocene deposits covered by the Pliocene-Quaternary marine and alluvial deposits (Fig. 2). These turbidites, here considered the local substrate, are coarse-grained sandstones saturated by saline waters. The heat-flow from the Miocene substrate to the overlying fresh-water saturated sediments varies primarily as a function of the reservoir depth: from ten meters (Monticelli Terme) to a few hundred meters (Collecchio) and several hundred meters (Madregolo) below ground surface. In the culminations of the positive structure the temperatures detected in the Miocene reservoir vary from 40 to 50°C.

The temperatures measured in the overlying fresh-water aquifer are highly variable. At Monticelli Terme the alluvial Late Pleistocene aquifer has a temperature around 20°C.

Temperature estimates show that the geothermal gradient in the thrust crest zone (4.7°C/100m) is about twice the gradient in the areas south and north (2.2°C/100m). Accordingly, the heat-flow is higher in the saturated alluvial sediments covering the thrust crest and front (0.06-0.07 W/m²) than in the alluvial wedge to the north (0.04 W/m²).

REFERENCES

CALDA N., VALLONI R. & BEDULLI F. (2007) - Three-Dimensional Representation of Permeability Barriers and Aquifers Recharge in the Pleistocene Deposits of the Parma Alluvial Plain. In R. VALLONI Ed: Proceedings Italian National Workshop "Developments in Aquifer Sedimentology and Ground Water Flow Studies in Italy", Parma June 2004, S.EL.CA. Firenze, Memorie Descrittive Carta Geologica d'Italia, Roma, **76**, 97-108.

PIERI M. & GROPPI G. (1981) - *Subsurface Geological Structure of the Po Plain, Italy.* Pubblicazione C.N.R. n° **414**, Progetto Finalizzato Geodinamica, 13 pp.

RER & ENI-AGIP (1998) - *Riserve idriche sotterranee della Regione Emilia-Romagna*. A cura di G. DI DIO. S.EL.CA., Firenze, pp. 120