Bottom hole temperature correction for geothermal potential assessment: the Eastern Po Plain case study

T. Nanni[1], G. Gola[1], V. Cortassa[2], A. Galgaro[3], M. Tesauro[2,4], R. Basant[2], A. Manzella[1]

[1] *Institute Geosciences and Georesources, National Research Council, Italy*
[2] *Department of Mathematics, Informatics and Geosciences, University of Trieste, Italy*
[3] *Department of Geosciences, University of Padova, Italy*
[4] *Department of Earth Sciences, Utrecht University, Netherlands*

With the massive expansion of renewable energy demand, the InGEO Project (Innovation in geothermal resource and reserve potential assessment for the decarbonization of power/thermal sectors) aims at developing and testing an innovative, multidisciplinary exploration workflow to assess the geothermal potential for power generation and direct uses of thermal energy. The InGEO Project selected the buried Romagna and Ferrara folds sector (Eastern Po Plain, Italy) as case study.

The essential parameters for the evaluation of the geothermal resources, in terms of spatial and vertical distribution, are the undisturbed formation temperatures and litostratigraphic information from deep hydrocarbon and geothermal exploratory wells. In this context, data collection and critical review of the available temperature data are fundamental activities. Different catalogues are available and freely accessible: the Italian National Geothermal Database (Trumpy & Manzella, 2017), the Global Heat Flow Database (GHFD), temperature data from bibliographic sources (Agip, 1977 and following updates), technical reports (consultable from the ViDEPI project website), and scientific studies (Pasquale et al., 2008).

Temperature data can be divided in two main categories: Drill Stem Test (DST) and Bottom Hole Temperature (BHT). DST data can be considered representative of the undisturbed thermal regime. Conversely, BHT data usually underestimate the real formation temperature. In this strudy, we applied different methods to correct the raw BHT data. Time temperature series were corrected with the Horner method (Horner, 1951). In case the circulation time was unknown, we estimated it by the relation proposed by Pasquale et. al. (2008). In Figure 1 some Horner applications are displayed. In most cases we observed a constant increase of temperature as function of the shut-in time resulting in a negative Horner slope. The calculated formation temperature results greater than the measured raw temperatures (Figure 1a and 1b). Nevertheless, in few boreholes a decreasing temperature trend was observed, resulting in positive Horner slopes and a lower extrapolated temperature. This behaviour can be explained invoking different external perturbation effects. For example, in Montecchio 1, the shallow time temperature series reflect the warming effect of the drilling mud circulation on the near surface geological layers, which can occur at depths lower than 1000 m (Figure 1c and 1d). In this case, even if the Horner slope is positive, the correction was considered reliable. In offshore areas, the cooling effect induced by cold sea water infiltration cannot be neglected. For example, in Ginevra 1 well, we observe a decreasing trend with time giving an extrapolated anomalously low temperature constraining a geothermal gradient of about 13 °C/km (Figure 1e and 1f). In this case, the Horner correction was discarded. To validate the results obtained with the Horner method, we compared the calculated undisturbed formation temperatures against those reported by oil companies, obtained by the graphical method of Fertl-Wichman (1977). The comparison shows differences << 1% (Figure 2).

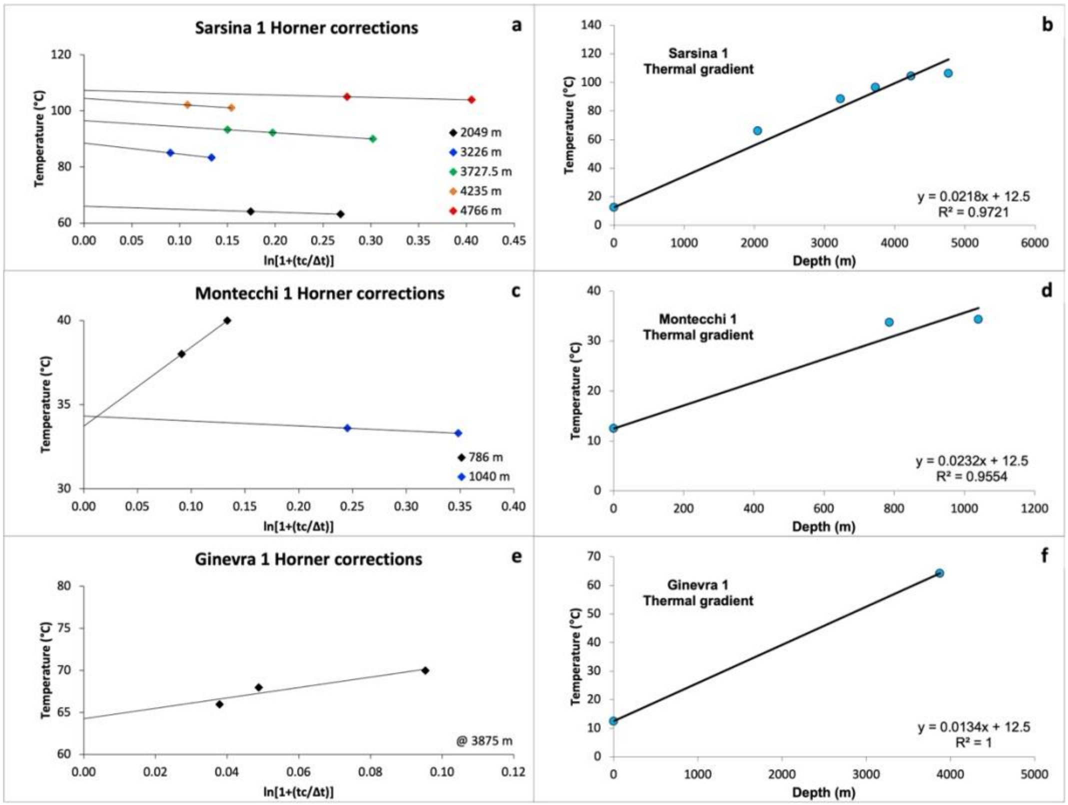

Fig. 1 – Horner method applied to correct time temperature series for Sarsina 1 (a), Montecchi 1 (c) and Ginevra 1 (e) deep hydrocarbon exploratory wells. Thermal gradient estimation for Sarsina 1 (b), Montecchi 1 (d) and Ginevra 1 (f) boreholes.

After the correction of BHT data, the undisturbed temperatures represent a reliable dataset that can be used for estimating the distribution of temperature at depth and the site-specific heat flow value. In conclusion, a data quality control and the application of a robust correction method are very important to assess the underground thermal field for geothermal potential assessment studies.

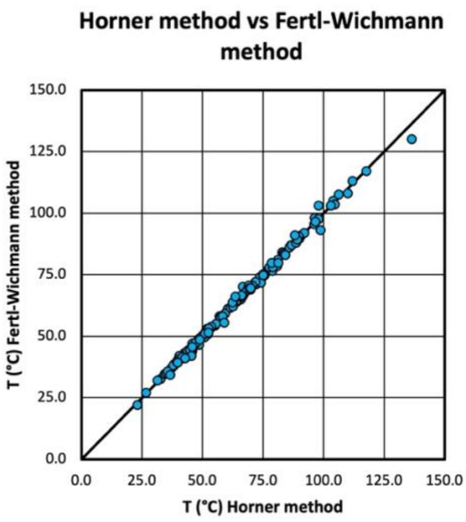

Fig. 2 – Comparison between the undisturbed formation temperatures calculated with the Horner and the Fertl-Wichman methods. Black line represents the 1:1 relationship.

References

Agip; 1977: Temperature Sotterranee, Inventario dei dati raccolti durante la ricerca e la produzione di idrocarburi in Italia. AGIP, Milano, p. 1930.

Fertl W.H. & Wichman P.A.; 1977: How to Determine Static BHT from Well Log Data. World Oil, 105-106.

Horner, D. R.; 1951: Pressure build-up in wells. In: Proc. 3rdWorld Petroleum Congress, The Hague, The Netherlands, 503 – 519.

Pasquale V., Chiozzi P., Gola G. and Verdoya M.; 2008: Depth-time correction of petroleum bottom-hole temperatures in the Po Plain, Italy. Geophysics, 73, 187 – 196.

Trumpy E. & Manzella A.; 2017: “Geothopica and the interactive analysis and visualization of the updated Italian National Geothermal Database,” International Journal of Applied Earth Observation and Geoinformation, vol. 54, pp. 28–37.

Videpi Web site: https://www.videpi.com Last access: 13/12/2024

Corresponding author: thomas.nanni@igg.cnr.it