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

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Innovation in **GEO**thermal resources and reserves potential assessment for the decarbonization of power/thermal sectors

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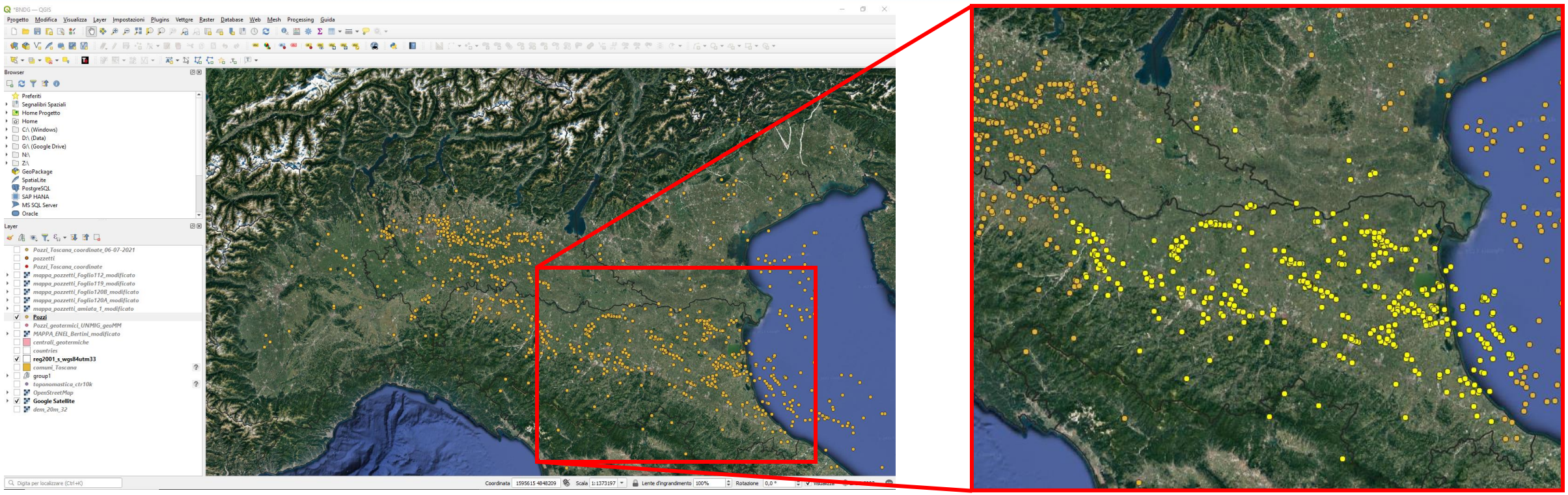

Geothopica → in Italia circa 3800 pozzi in totale

→ Selezionati circa 560

Disponibilità Pdf Profilo Finale di pozzo da Progetto Videpi.
Aggiornamento BNDG: Anagrafica, Coordinate, Deviazioni, Litostratigrafia e **BHT**, **Unità Litotermiche, Dati di Flusso**

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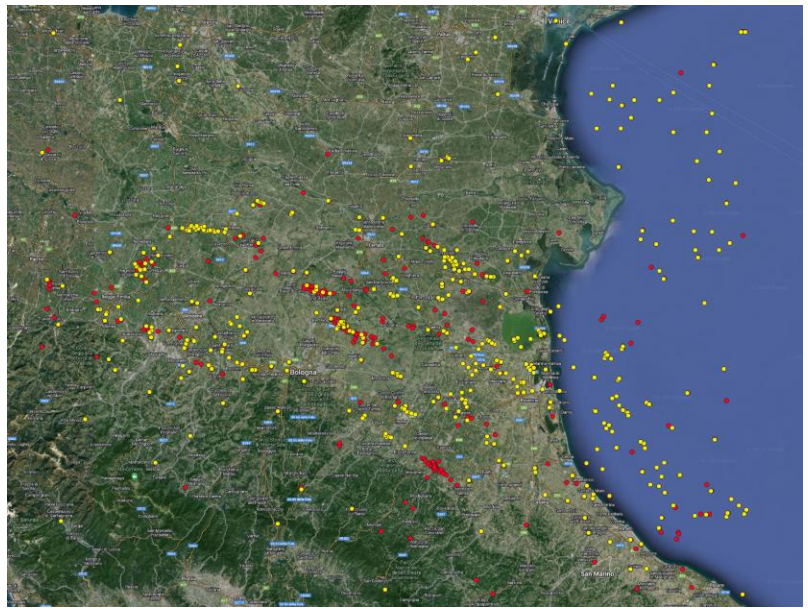
DATA COLLECTION AND UPDATING

Borehole data

A total of 838 boreholes of which:

- 666 with temperature and lithostratigraphic data;
- 167 with lithostatigraphic data;
- 5 with temperature data;



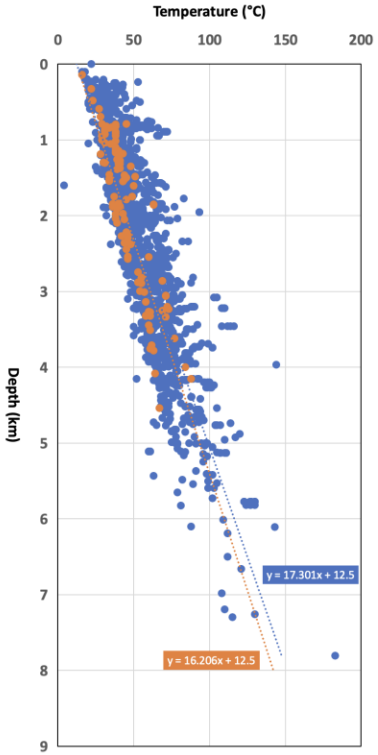
Boreholes from BNDG

Boreholes from Videpi and AGIP (1977, 1987)

Underground thermal data

The results of data collection are:

- A total of about 1500 raw BHT data, of which 500 BHTs are time-temperature series which provided 151 SBHT (Horner method) and 1000 BHTs are single temperature data with known shut-in-time.
- A total of about 500 raw BHTs without shut-in-time cannot be corrected.
- A total of about 450 SBHT (Fertl-Wichmann method).
- A total of 121 Drill Stem Test (DST) temperature data.



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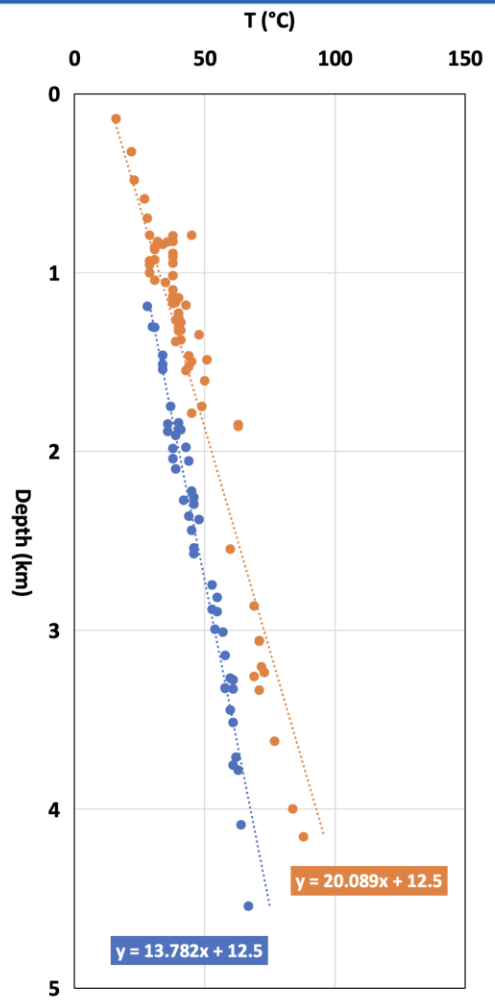
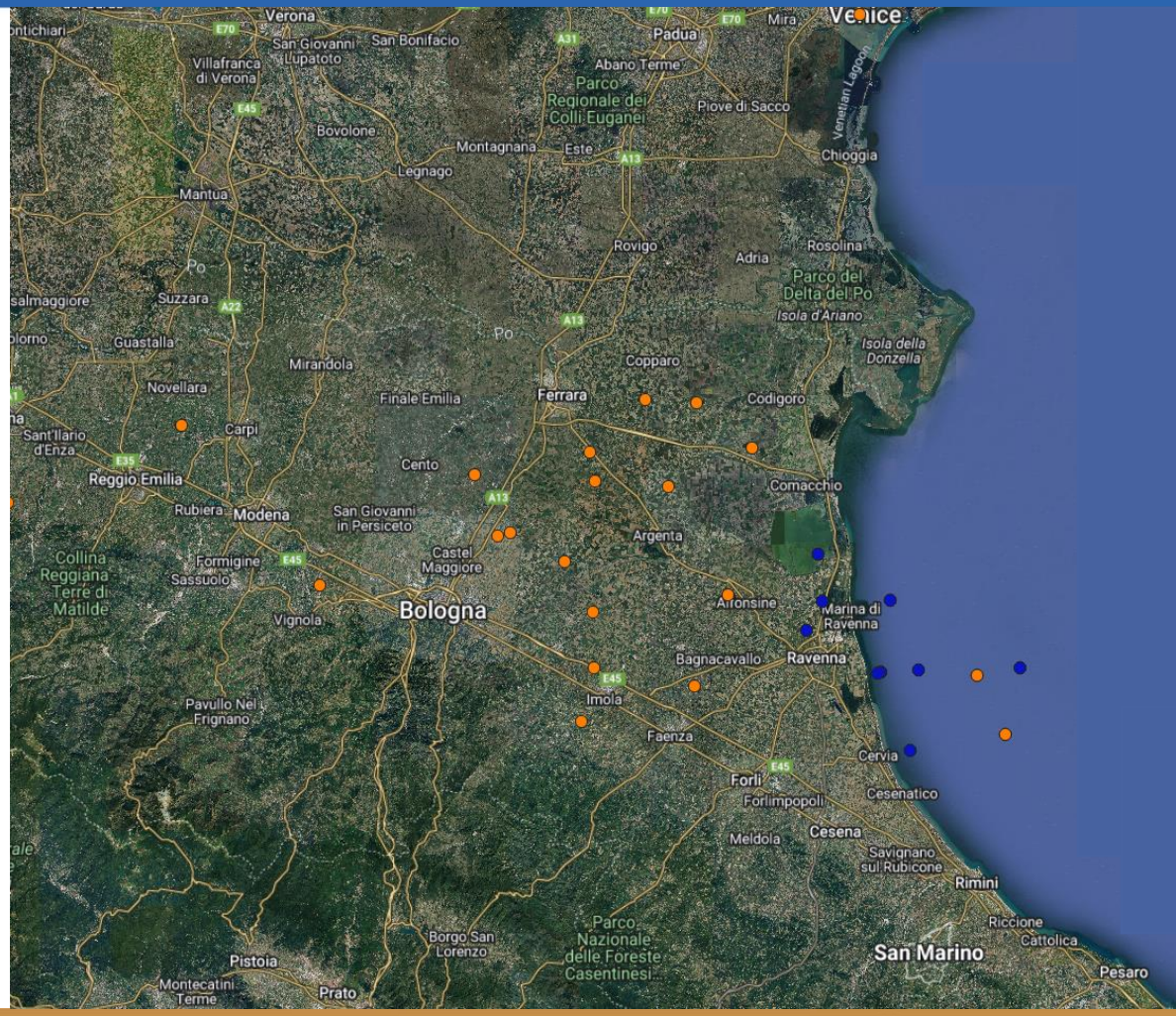
DST THERMAL GRADIENT

DST data highlight 2 thermal regimes: show two different families of data, corresponding at:

- Cluster 1 (orange): 20 °C/km
- Cluster 2 (blue): 14 °C/km

The mapping of DST data shows that the cluster 1 relies to the on-land pools, cluster 2 relies to the offshore pools.



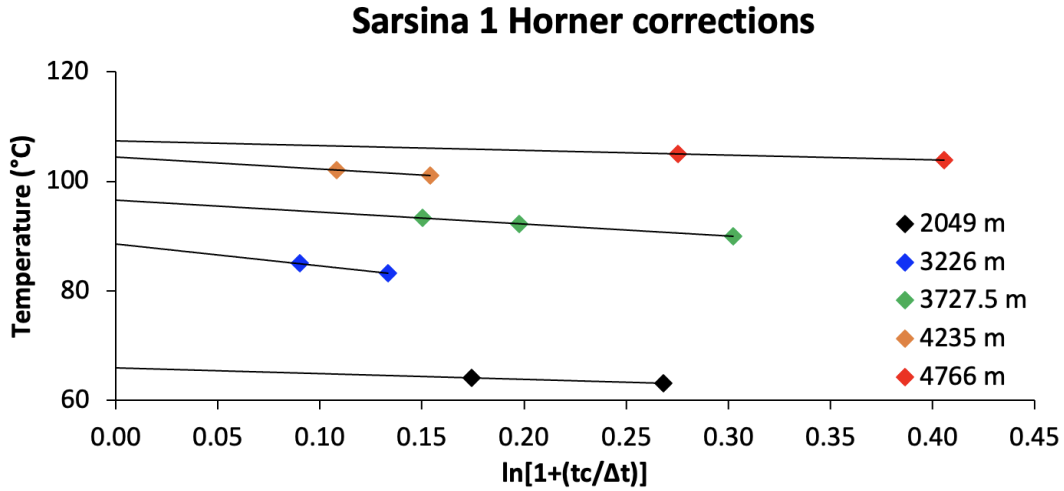


CORRECTION OF TIME-TEMPERATURE SERIES: HORNER METHOD

Horner method (1951) is based on the linear source theory:

$$BHT(\mathrm{t}) = SBHT + \left(\frac{H}{4\pi k}\right) * ln\left(1 + \frac{t_c}{\Delta t}\right)$$

Data needed circulation mud time (t_c) and shut-in-time (Δt) to extrapolate the static bottom hole temperature (SBHT)



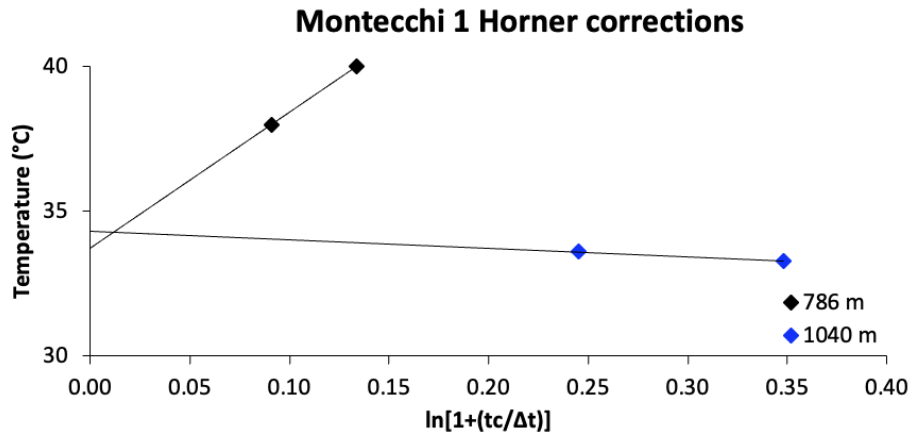
HORNER METHOD: PARTICULAR CASES

Usually the Horner slope is negative (temperature increases with time), but:

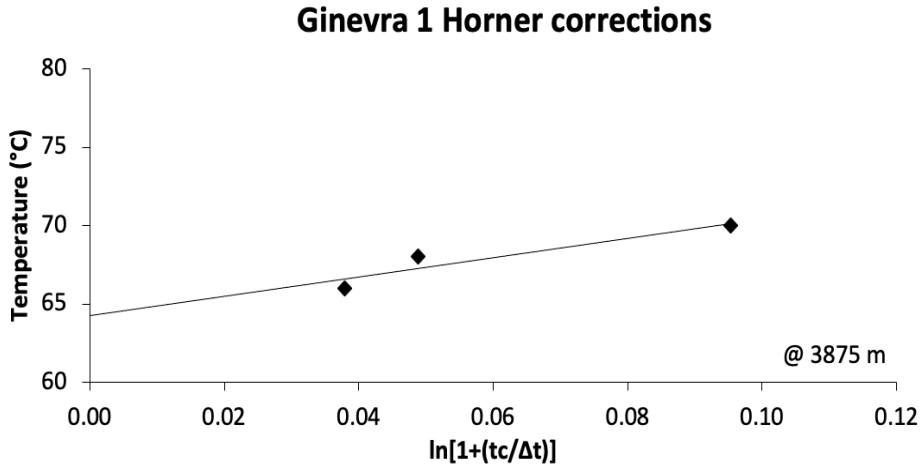
1) near surface rocks (z < 1 km) could be warmed by the circulation mud during drilling. We observe a decreasing temperature trend during thermal recovery;

2) In offshore wells the infiltration of cold seawater from seabottom induces a cooling effect during thermal recovery.

1)

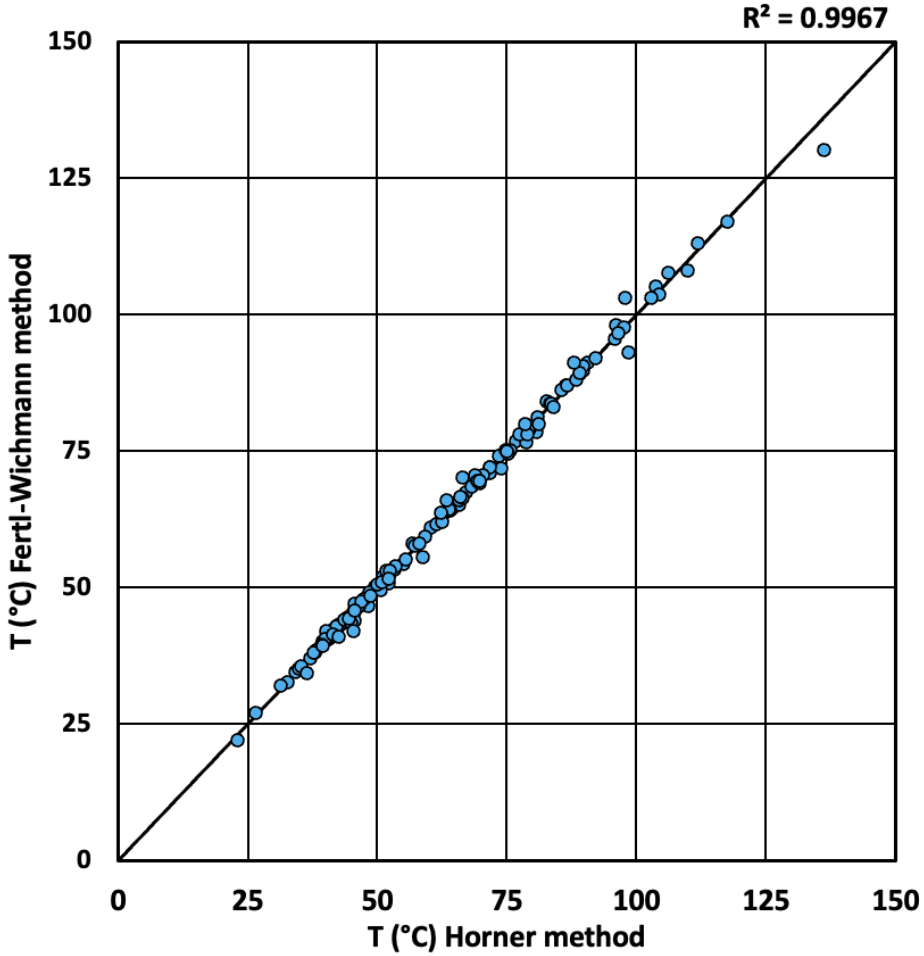


2)



TEMPERATURE DATA CORRECTION: HONER METHOD VS FERTL-WICHMANN METHOD

O&G companies usually apply to the time temperature series the graphical method of Fertl-Wichmann. The comparison between Horner and Fertl-Wichmann methods shows that both approaches provide similar results.



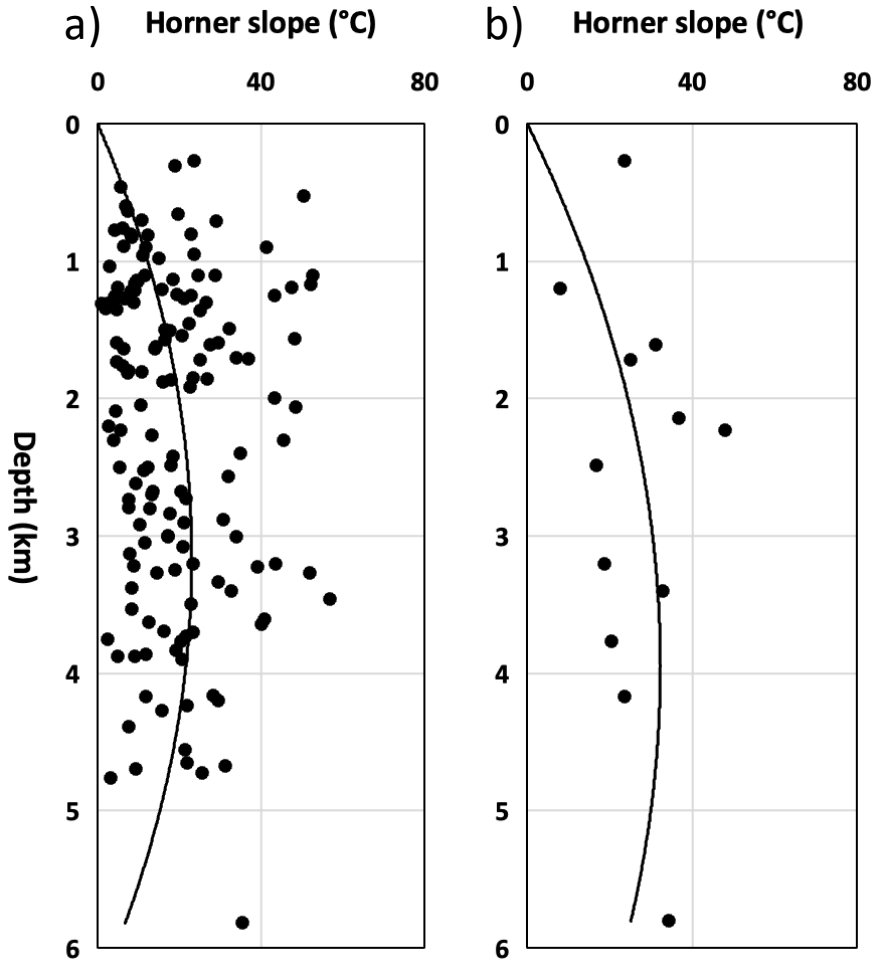
SINGLE TEMPERATURE DATA CORRECTION: CALIBRATE EMPIRICAL LAW

$$BHT(\mathrm{t}) = SBHT + \left(\frac{H}{4\pi k}\right) * ln\left(1 + \frac{t_c}{\Delta t}\right)$$

Given that the Horner slope is proportional to the borehole heating rate, we calibrated an empirical 2nd-order polynomial function which enable us to correct the single BHT as function of t_c, Δt and depth (z).

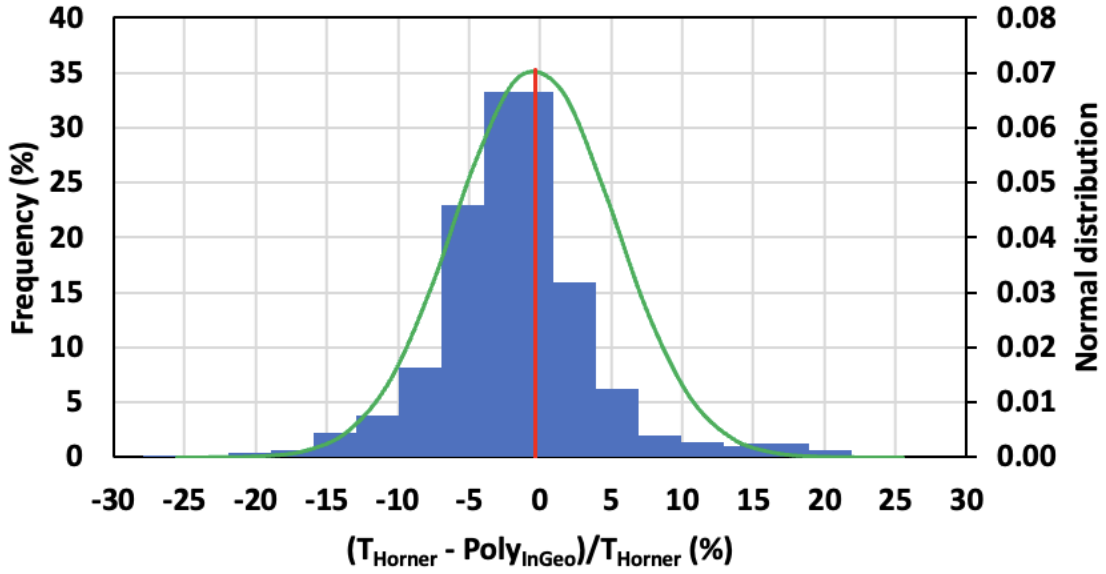
$$\Delta T = (14.2z - 2.3z^2) * ln\left(1 + \frac{t_c}{\Delta_t}\right)$$

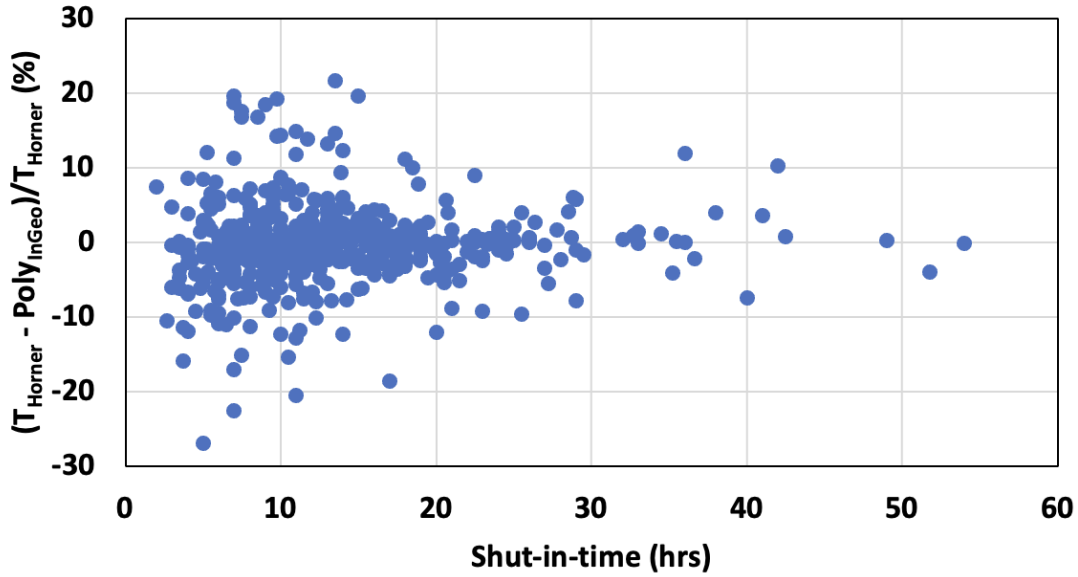
InGeo project calibrated the empirical correction formula using 151 Horner slope data (a) improving the previous correction calibrated by only 12 Horner slope data (b).



VALIDATION OF THE EMPIRICAL CORRECTION

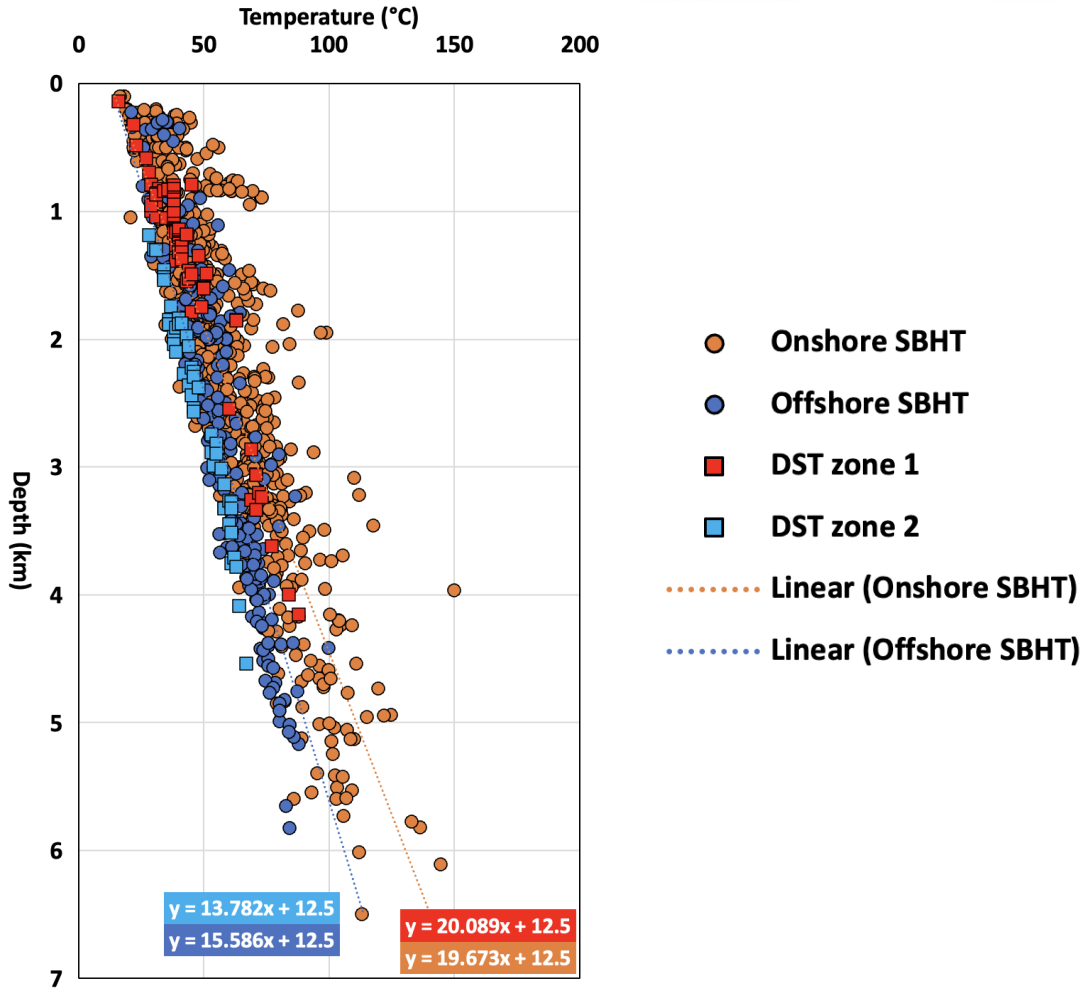
To validate the empirical correction, we compared the Horner-method equilibrated temperatures against the time temperature series considered as single temperatures corrected with the empirical formula.



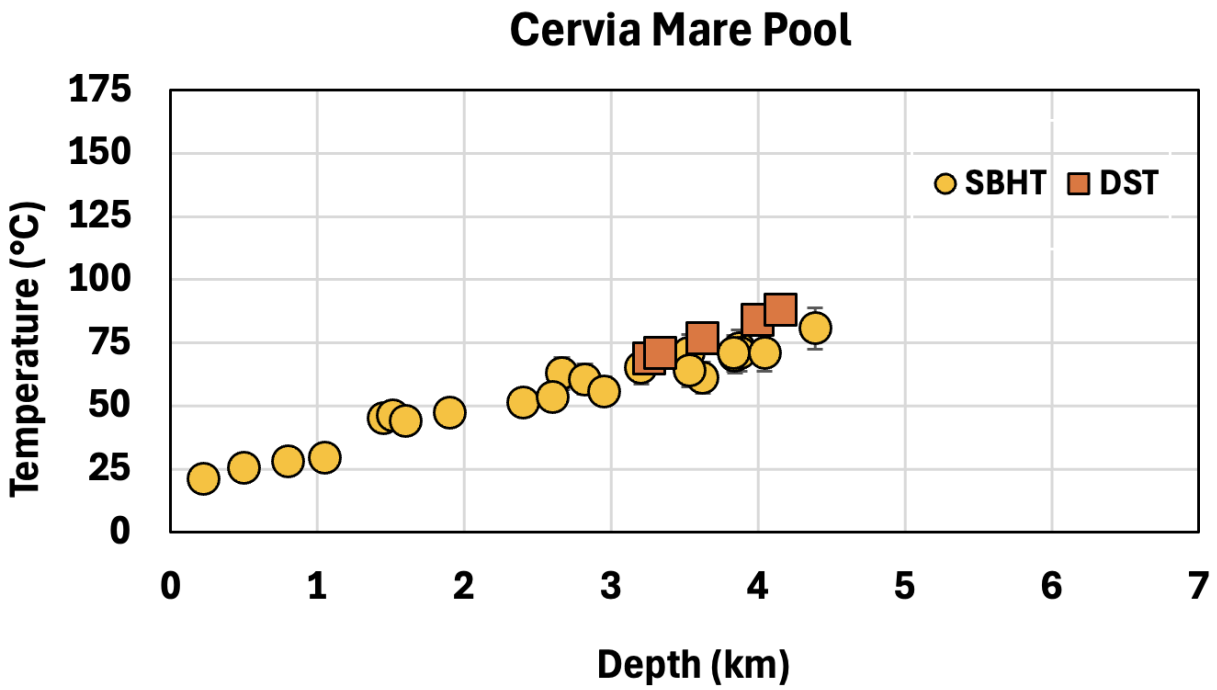


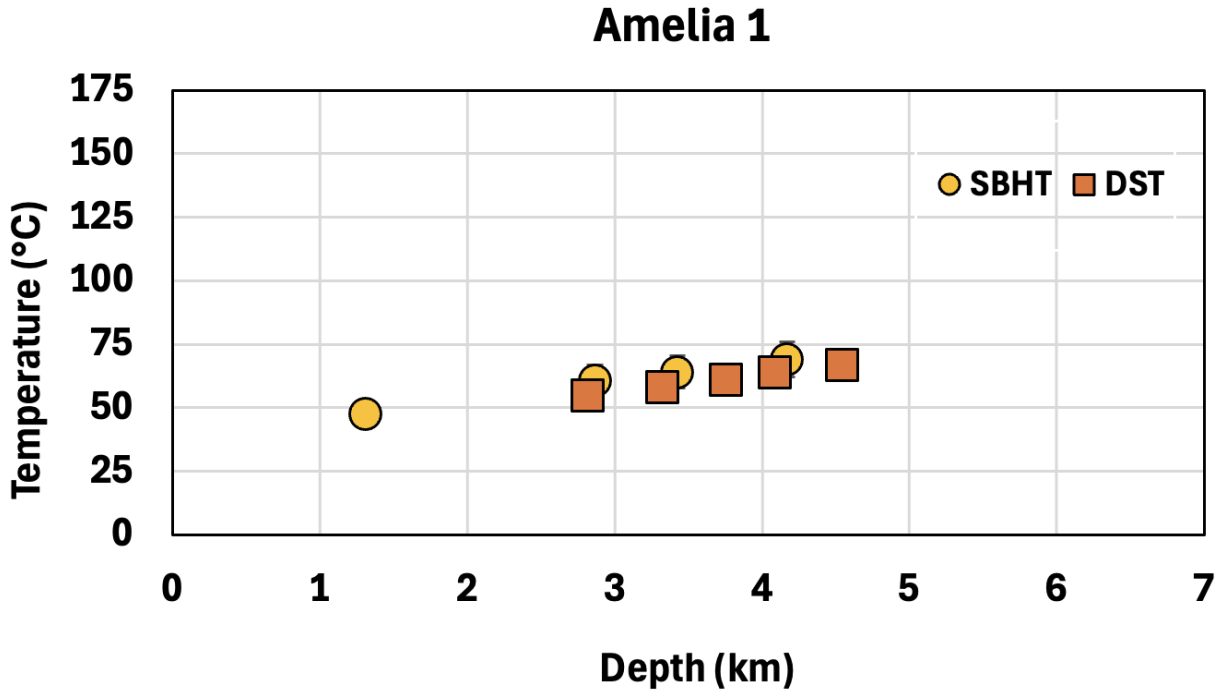
FINAL DATASET

The final dataset was create using all corrected data (SBHT and DST). The gradient comparison between SBHT data and DST data of two different thermal regimes show a good agreement.



FINAL DATASET





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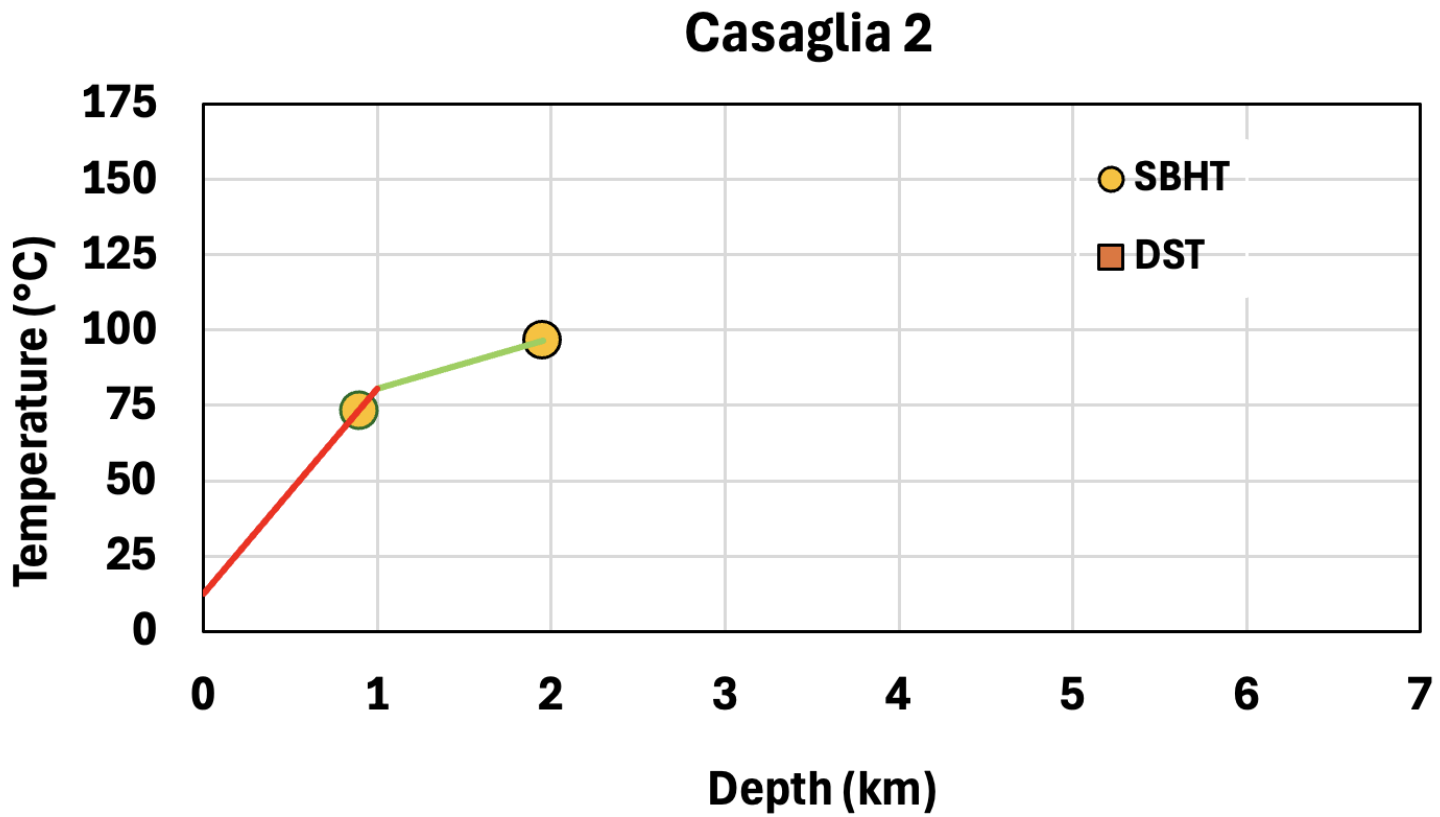

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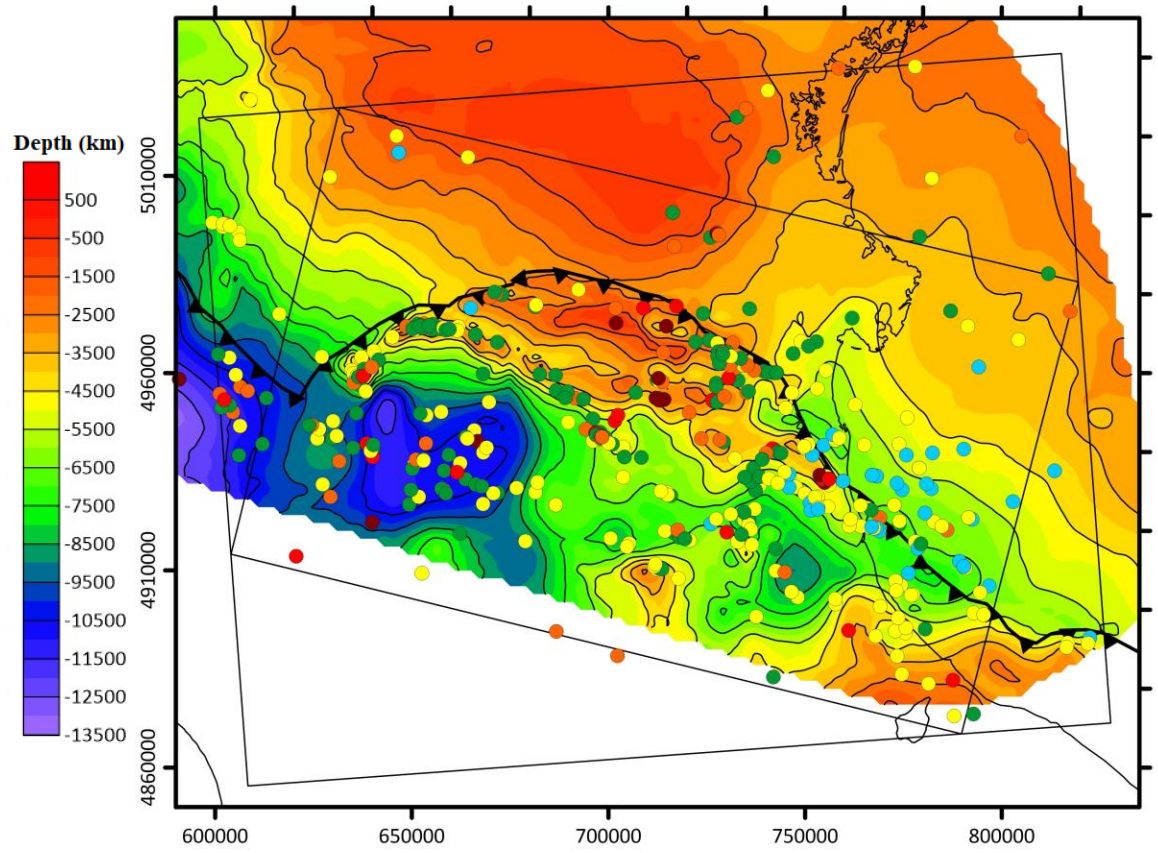
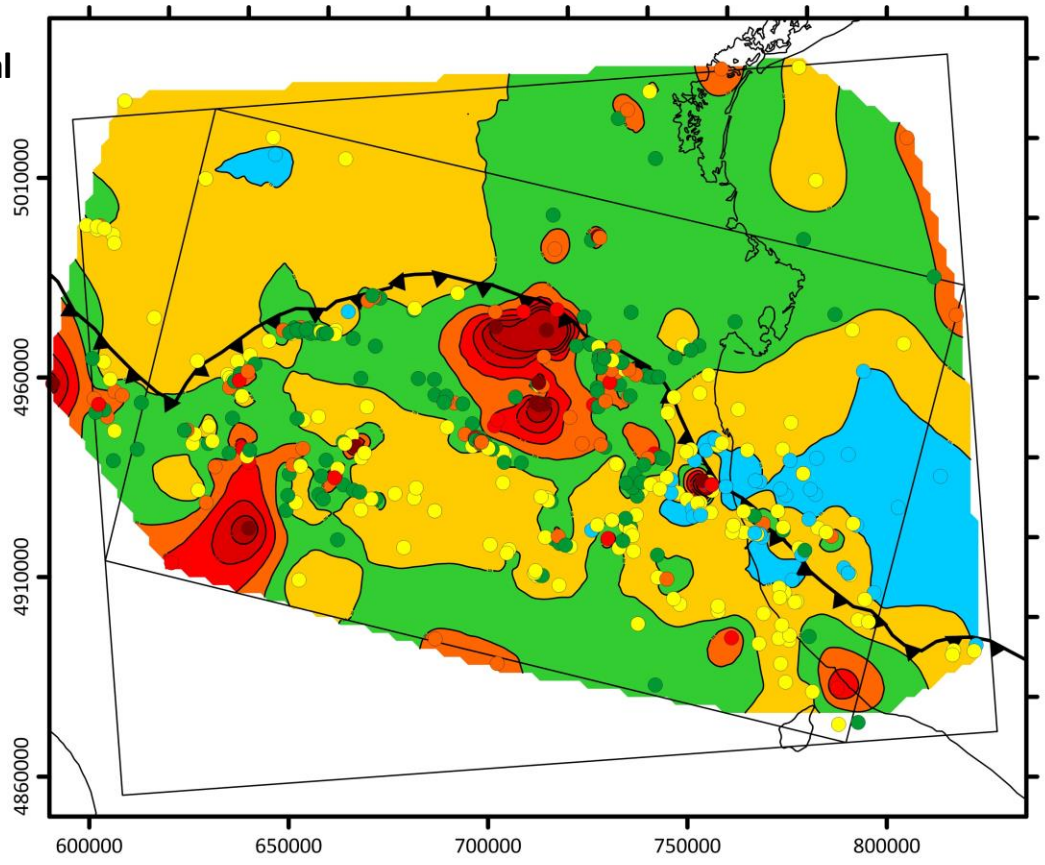
GRADIENT MAP



Site thermal gradient (°C/km)

- >45
- 40-45
- 35-40
- 30-35
- 25-30
- 20-25
- 15-20
- 10-15
- 5-10



CONCLUSIONS

- DSTs data show two different thermal regimes in the study area.
- Horner slope is useful to generate an empirical law for the correction of single BHTs data.
- Site specific thermal gradients from SBHTs data and DSTs are in good agreement.
- A positive thermal anomaly was recognised in culmination of overthrust.

Thanks for your attention

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