

Supplementary material to the article "Influence of the regional topography on the remote emplacement of hydrothermal systems with examples of Ticsani and Ubina volcanoes, Southern Peru".

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The document contains following figures referenced in the main text:

1. Google Earth image of Ticsani complex location of self-potential profile used for numerical modeling.
2. Location of the self-potential profile at Ubina volcano. Plot of temperature of the hot springs at Ubina versus elevation.
3. Ground temperature measured at Ticsani as function of the elevation.
4. Physical properties used in numerical models.
5. Ground temperature corrected for elevation effect.
6. Locations and temperatures of the hot springs in vicinity of the Ticsani volcano as function of distance and elevation.
7. Position of hydrothermal system as a function of permeability in A model geometry.
8. Electric conductivity of the hot springs and its temperature dependence.
9. Self-potential response corresponding to different water table elevations obtained in B model.



Figure 1: Google Earth view of Ticsani complex with a position of Pr1 and circular profiles illustrating regional topographic variations.

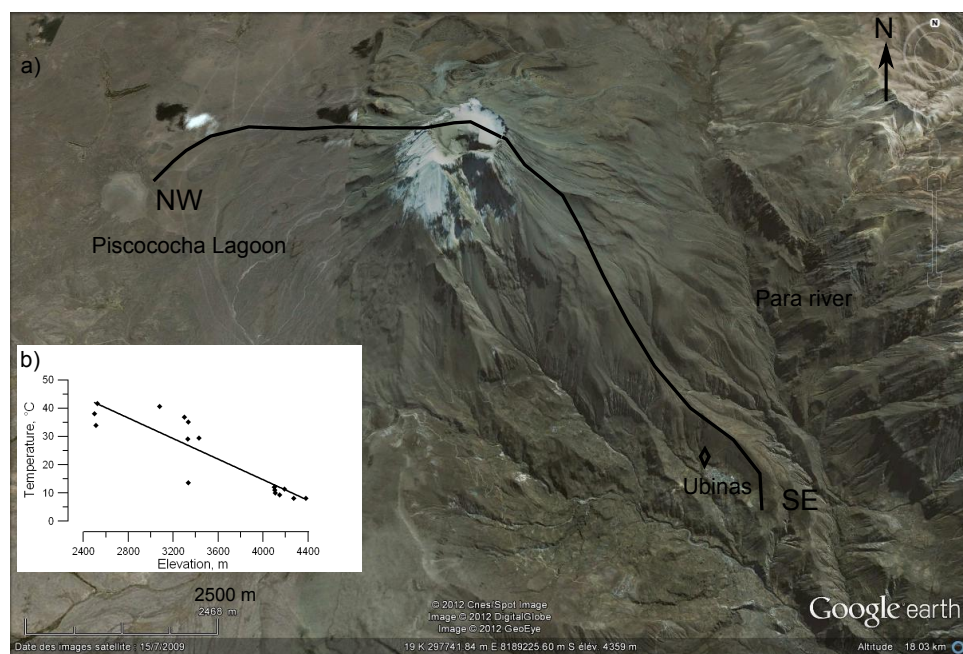


Figure 2: a) Google Earth view of Ubinas with location of a self-potential profile. Location of the spring Termal Ubinas is shown with black diamond. b) Temperature of the hot springs associated with Ubinas volcano versus elevation. Data after Cruz et al, 2006.

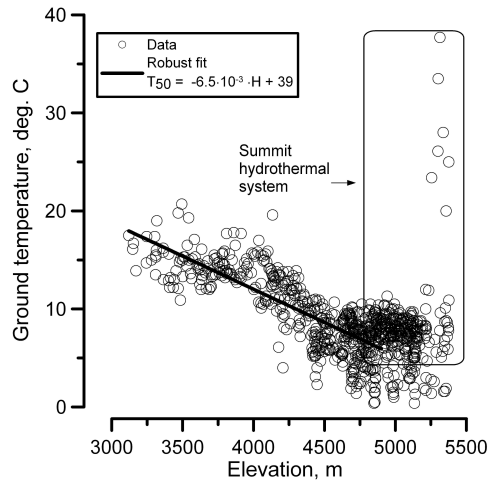


Figure 3: Ground temperature T_g at Ticsani volcano at 50 cm depth versus elevation H . Solid line shows the robust fit -6.5 K per 1000 m altitude, corresponding to the temperature decrease in the neutral atmosphere. Deviation from the fit for elevations exceeding 4800 m evidences a summit hydrothermal system. The relationship between ground temperatures and the elevation is well-described by a linear fit between 3100 and 4800 m asl, with a slope of -6.5°C per 1 kilometer of altitude. Therefore we decided to correct the temperatures for this trend; the corrected temperatures are displayed in Figure 4.

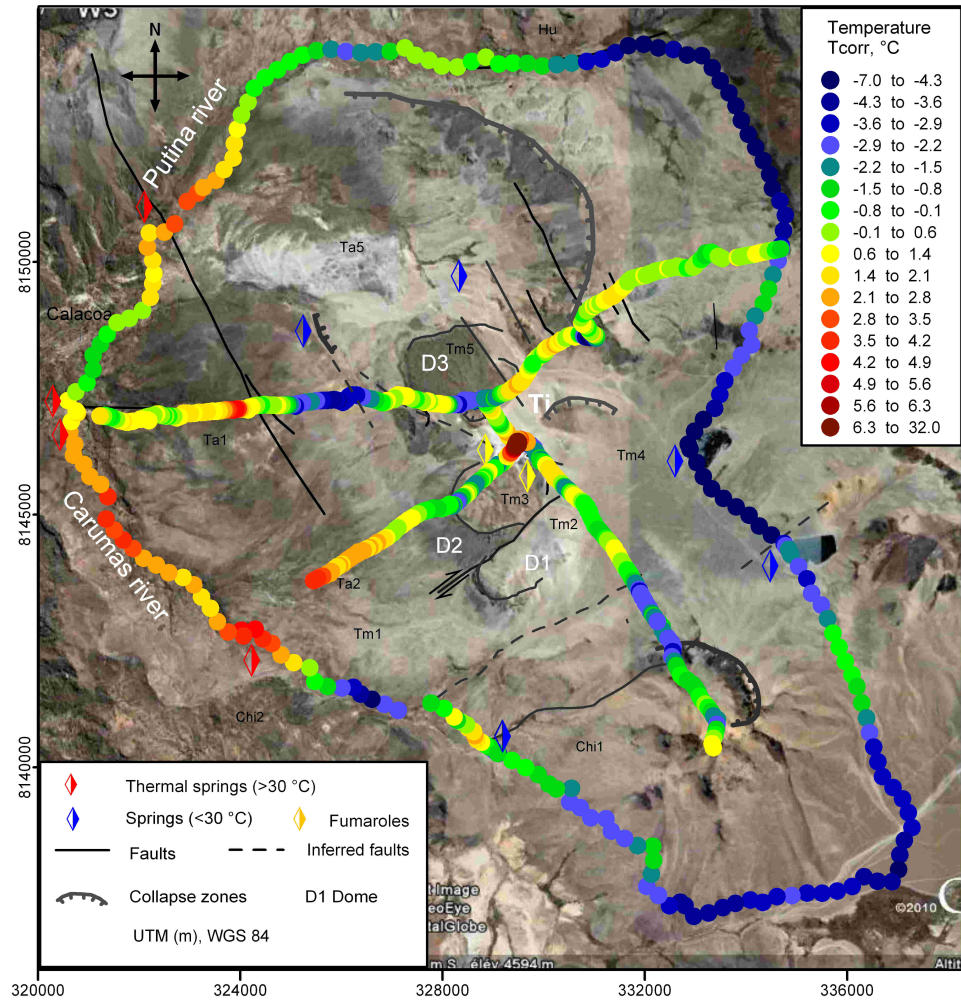


Figure 4: Ticsani ground temperature data corrected for elevation effect superimposed on the Spot Google Earth image of the studied area.

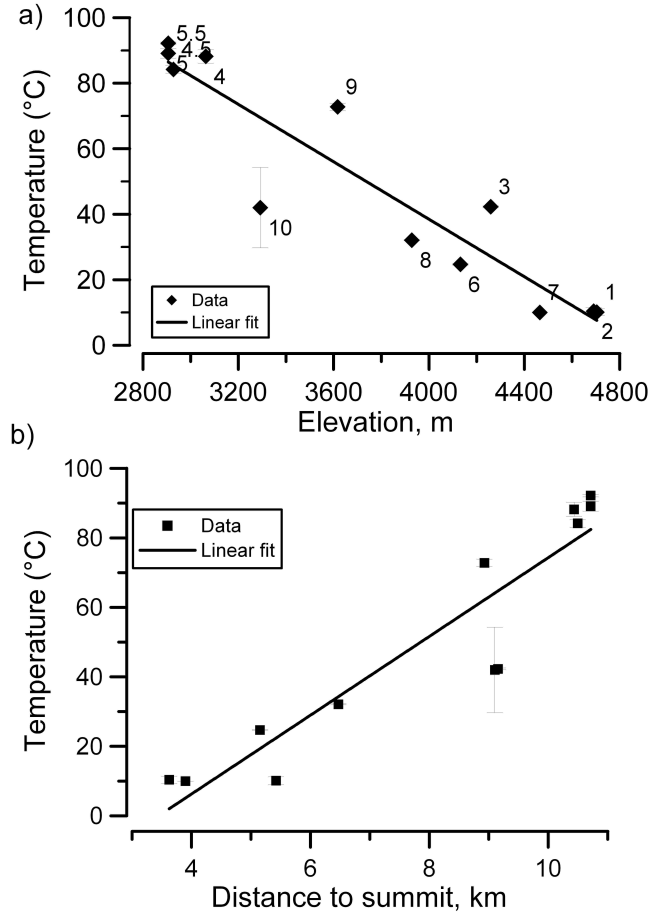


Figure 5: a) Temperature of the hot springs T_{spr} at Ticsani volcano listed in Table 1 versus elevation H . b) Temperature versus distance d to the summit for the same hot springs.

Table 1: Springs and fumaroles in the vicinity of Ticsani volcano whose locations are shown in Figure 2 a of the article by the same numbers as in the table

Location	Longitude [m]	Latitude [m]	Elevation [m]	T [°C]	δT [°C]	EC(25°C) [S m ⁻¹]
1. Laguna T. Bravo	334754	8144433	4704	10.1	2.2	0.05
2. Laguna Camaña	332869	8144636	4691	10.4	2.1	0.06
3. Hierva Buena	320563	8146953	4459	42.3	0.5	0.2
4a. PA. 1	319623	8149105	3064	88.2	4.1	0.37
4b. PA. 2	319545	8149046	2928	84.2	2.3	0.29
6. Ticsani-1	325390	8149218	4132	24.7	0.44	0.08
7. Ticsani-2	328837	8150200	4465	10	—	0.01
8. RFT	324404	8142680	3928	32.1	0.3	0.08
9. Secolaque	322090	8151066	3617	72.8	2.2	0.23
10. Cuchumbaya	320637	8147230	3292	42	24.5	—
11. TSC Fumaroles	329662	8146413	5397	79	—	—

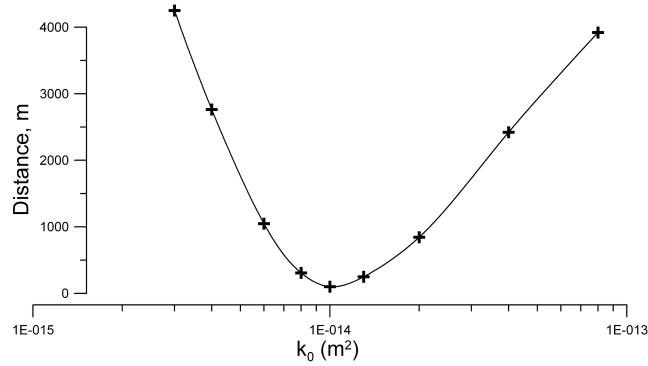


Figure 6: Distance d between the hydrothermal system given by A model and observed hydrothermal area as a function of surface permeability k_0 . The distance d is given by $d = \sqrt{[(z_m - z_d)^2 + (x_m - x_d)^2]}$, where z_m , x_m are height and horizontal distance from summit of hydraulic conductivity maximum. z_d and x_d are height and horizontal distance from summit of the hot springs PA1-PA2 with maximal temperature.

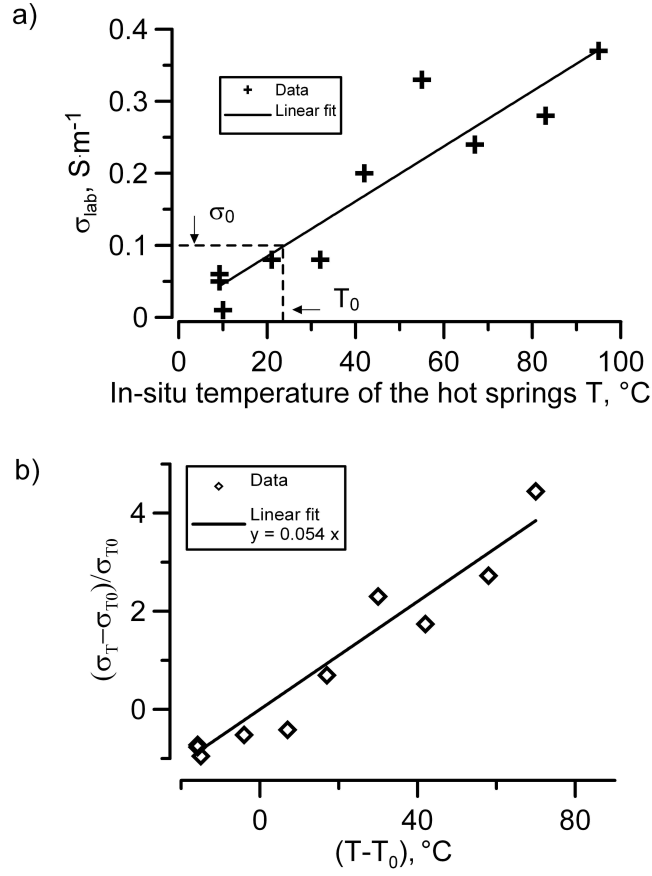


Figure 7: a) Electric conductivity σ_{lab} of the samples of hot spring water measured at $T_0 = 25^{\circ}C$ versus in-situ temperature of the hot springs. The temperature dependence here accounts for the mineralization of the pore water. b) Least square estimation of the total temperature coefficient for conductivity of the hot springs $\alpha = (\sigma_T - \sigma_{T_0})/(T - T_0) \approx 0.05 K^{-1}$

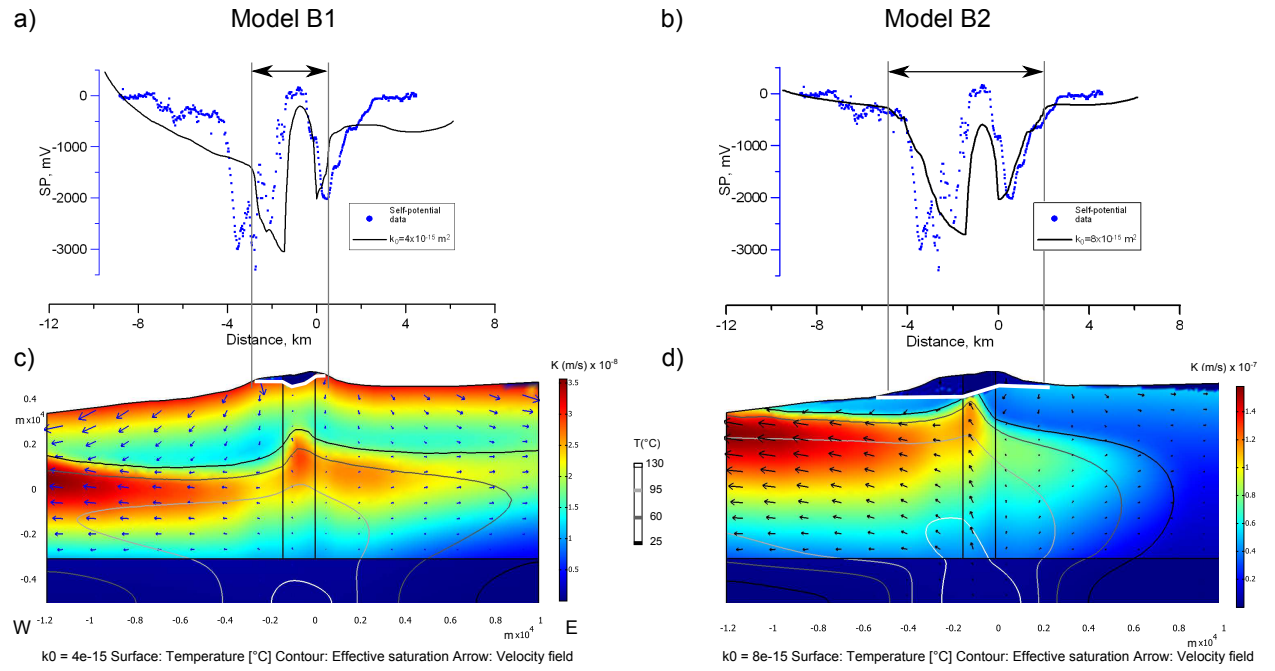


Figure 8: Water table position (white line) and self potential for different permeability values. Model results from thermodynamic model coupled with electrokinetic problem: a, c) for $k_0 = 4 \times 10^{-15} \text{ m}^2$ and b, d) for best model B2 $k_0 = 8 \times 10^{-15} \text{ m}^2$. The two negative lobes of the self-potential anomaly correspond to the rain water infiltration in the vadose zone indicating the position of the water table in agreement with calculated water table position shown with white solid line in c and d).