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Identification of shallow geothermal anomalies in the Timanfaya National Park (Lanzarote, Canary Islands) through combined geophysical prospecting techniques

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The Timanfaya National Park is a volcanic area in the southwest of Lanzarote Island (Canary Archipelago, Spain) resulting from the 1730-1736 eruption period. Several active geothermal anomalies have been identified from 1970's. Their location is important to prevent hazards in this restricted touristic area of the park. Presently, only some regional geophysical studies based on gravity, magnetic and seismic data have been undertaken to model the crustal structure of Lanzarote Island.

This work presents a new study about the geothermal anomalies in the Timanfaya National Park by the analysis and joint interpretation of electrical resistivity tomography (ERT), magnetic anomalies and electromagnetic induction data (EMI). All analyzed data have been obtained over areas which had not been surveyed before. The studied geothermal field is located at the Islote de Hilario visitor's centre.

One 50m-long GPR profile was carried out in May 2012 along the location of a known geothermal anomaly developed over pyroclastic deposits. The two main characteristics are: a) no continuous subhorizontal reflections are displayed up to $\sim$12 m depth and, b) the intensity of the reflections varies laterally in good agreement with the location of the geothermal anomalies (the higher the ground temperature, the greater the intensity of the GPR signal). Thus, an outline of the subsurface area with higher temperatures can be observed, indicating that the heat source is deeper at the beginning of the profile and extends laterally and progressively shallower towards the end. Temporal variation of the shallow temperature distribution was also investigated by repeating the same GPR profile in April 2015. Although both profiles look quite similar, subtle variations of the GPR signal intensity suggest a certain temporal variation of the ground temperature.

In November 2012 a land magnetic survey was carried out in Timanfaya. In the Islote de Hilario area, total field magnetic data were acquired with an Overhauser magnetometer following a 75m-long profile which coincides in the first 50 m with the GPR profile. Three additional profiles (two of them parallel and one orthogonal to the first one) completed the survey, allowing the interpolation of the data into a regular grid. The resulting reduced-to-the-pole anomaly map displays some magnetic lows which could be related with high temperatures at shallow depths causing the loss of magnetic properties within the subsurface volcanic rocks. Forward modelling has been carried out to characterize the magnetic sources and to analyze the correlations with GPR data. These models have been constrained with NRM and susceptibility data measured in the laboratory for samples from the Timanfaya lava flows.

Preliminary results of EMI data show high resistivity areas in good agreement with the location of the shallow geothermal anomalies, the magnetic lows and the high GPR signal intensity.

The comparison of the results obtained from the different techniques reveals that the joint interpretation of ERT, magnetic anomalies and EMI methods provides reliable models useful for the location of shallow geothermal anomalies. These non-destructive geophysical techniques are of crucial importance in areas of special protection such as National Parks.