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Geospatial analysis of thermal and structural data for the characterization of shallow geothermal systems: the Parco Naturalistico delle Biancane (Tuscany/Central Italy) study case

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Geothermal energy plays a major role in the energy transition context. This presents a constant increasing rate in electricity generation, even if it today represents a smaller part of the renewable energy package. To sustain this natural resource, it is necessary to better understand the geotectonic framework of key places that are historically relevant in terms of innovation, exploration and development of geothermal energy resources. These places represent strategic cases study: i) to better understand the surface manifestation related to a geothermal area; ii) to test new methodologies that can help in the monitoring and identification of new natural resource; iii) to better understand the geodynamic context that characterizes the geothermal area in terms of thermal anomalies, soil alteration, stress field, and fracture distribution inducing secondary permeability.

This work is linked to a PhD project focused on Parco Naturalistico delle Biancane (PNB) area, in southern Tuscany (Italy), the main Italian geothermal region, where geothermal energy production started in 1916.

The aim of the project was to merge original remote sensing techniques and classical structural geology field data to improve the knowledge of the geological setting of PNB geothermal area. Deepening the confidence on this methodological approach, some considerations on its exportability has been carried out. According to the methodology a remote sensed analysis has been performed, leading us to highlights the correlation between the morpho-geological and geothermal features, in terms of thermal anomalies. An automatic lineaments detection has been done by analyzing Digital Elevation Model (DEM) and Land Surface Temperature (LST) maps derived from Landsat8 satellite data. The results obtained by this analysis highlights the NE-SW lineaments domain as the most relevant from both point of view: thermal and structural. The analysis shows a good relationship between the two datasets and allowed to understand how tectonic setting acts on shallow fluid circulation. These data have been compared with the field structural data including faults, joints, fault-synthetic cleavage, shear fractures and beddings. A multi scale spatial analysis has been conducted and includes: the structural data distribution,

density of the geo-morphological lineaments derived from the DEM, LST maps, high resolution surface temperature map, and surface classification map (based on ground spectral data acquired in the field). In this spatial analysis each dataset has been considered as a single, independent layer of information, and the spatial distribution of the “anomalies”, recognized in every layers, allowed us to identify and to define the areas that are strategically relevant to understand how a shallow geothermal system works and how to improve it.