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Three dimensional resistivity model of the Travale geothermal field (Italy)

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Electromagnetic methods, which have been widely used to study and characterize geothermal systems, have been tested in the Travale geothermal field (Italy). In this high-enthalpy field the exploration targets are located in metamorphic and magmatic rocks up to 4000-m depth, and are characterized by a high degree of heterogeneity and anisotropy and by the presence of superheated steam.

The results of previous studies carried out in this area have shown a significant reduction in electrical resistivity at the depth of the geothermal reservoirs. However, the origin of such reduction has not been fully identified: resistivity variations depends on lithology and on fluid distribution and state that are in turn controlled by temperature, pressure and tectonic processes. Hence, a multidisciplinary, integrated approach - using seismic, gravimetric, petrophysical and magnetotelluric data, as well as petrophysical analyses - is necessary to understand resistivity variation and to relate them to the lithological properties of the reservoir rock, to the kind and distribution of alterations and to the nature of the geothermal fluid.

As a first step in this multidisciplinary project, we have addressed the capability of electromagnetic induction methods exploiting magneto-telluric data to to define different reservoir features, and in particular a steam-dominated system. Starting from magnetotelluric data collected during different surveys, we have computed magnetotelluric transfer functions over a wide range of frequencies using a robust algorithm designed to extract magnetotelluric signals from electric and magnetic time series highly contaminated by correlated noise sources. As for the modeling, we have used previous information pertaining the distribution of lithological units in the area derived from a three-dimensional seismic survey. Resistivity models have been built in three different steps. First, a preliminary analysis using one dimensional modeling has been carried out for each station We have then computed a number of two-dimensional inversions (using a non-linear conjugate gradient regularised inversion algorithm) over a number of profiles (Five sections, with the orientation of 45˚E on the base of the main strike direction in the area (SW-NE) due to the Neogene basin orientation), using different boundary conditions, different values of deep resistivity layers and a set of a priori models . Such intermediate two-dimensional analysis has provided us with a robust evidence for the presence of a resistivity anomaly located at medium depth (4-5 km)þ.The corresponding information about the distribution of resistivity has then been used to construct a set of three-dimensional resistivity maps for the forward modeling (obtained varying the value and the shape of the resistivity anomaly), owing to a comparison between estimated and synthetic apparent resistivity and phase curves. A satisfactory agreement has been found between data-interpolated and computed resistivity pseudosections, while the main discordances were present in the south-west area, where the geothermal production is in fact reduced.

This analysis is the first step towards the definition of a full 3D resistivity model of the area, accounting for a three-dimensional a priori model for an inverse modeling.

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