Application of AEM to shallow geothermal potential mapping

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The "VIGOR" project aimed at assessing geothermal resources in 4 regions of Southern Italy. The SkyTEM survey is a part of the planned geophysical activities and has been chosen since it is able to collect resistivity data on wide areas, with great resolution and in short times. In this project AEM was tested in an area of known geothermal activities, and where a wealth of ancillary data is also present, in western Sicily. The results are composed in a 3D model of the electrical resistivity of the subsurface, and then interpreted for geothermal potential, following 2 main paths. The first is to produce a model of heat exchange capacity. The second aims at identifying directly conductive anomalies that might be associated to locally shallow hydrothermal fluids.

"Termini" area is covered by extensive geological surveys. Since geological conditions of Sicily, even at shallow depth, are very complex, this area provided a good place for defining the resistivity values of the main geological units outcropping in the region.

The "Western Sicily" area covers the main thermal manifestations of Western Sicily. Based on near real time preliminary results from the more regional mapping at 1 km line spacing, three infill areas were selected as being the most promising to test the concept.

The obtained resistivity volume has then been the base for a detailed lithological and geothermal interpretation. Lithological and geological maps were used to constrain surface condition and to understand the resistivity ranges of the different lithological units. On the base of AEM derived resistivity values, and of laboratory measurements of thermal and electrical conductivity on samples, it was possible to establish the main links between lithology, electrical resistivity and thermal conductivity. The work aimed at extending the correlation also at depth, producing a 3D model of thermal exchange capacity for the areas surveyed. This detailed interpretative modeling provides also the basis for detecting resistivity anomalies within carbonate units, which may possibly represent hydrogeological or hydrothermal bodies.

The AEM data inversion provided a wide 3D distribution of electrical resistivity with a maximum investigation depth up to few hundred meters. The geophysical results are composed by 3D cell distribution of resistivity (X,Y,Z, rho) from which resistivity slice maps and resistivity cross-section have been drawn. Figure 1 shows a 3D reconstruction of litho-resistive model of subsurface in the "Termini" area.

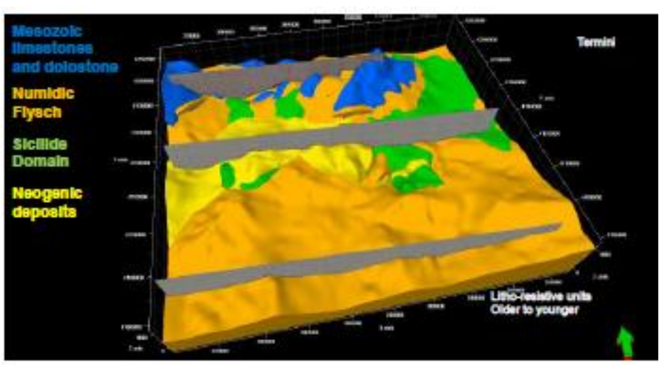

Figure 1

The detailed interpretative modelling was the occasion of recognizing resistivity anomalies within carbonate units, which host the regional hydrothermal reservoir. Some anomalies have been defined and are now under investigation to understand if they are due to shallow hydrothermal fluid circulation or other reasons, such as the presence of conductive components, e.g., clays. The litho-electrical 3D model is also under investigation to verify how it can represent a viable way to image heat exchange properties at shallow depth. If we succeed in defining the relations between electrical resistivity, lithology, thermal conductivity and hydrogeological bodies, we would obtain a way to define, at depth, the main parameters (thermal properties and fluid distribution) for defining shallow geothermal potential in detail. By comparison of thermal conductivity and surface resistivity, some meaningful correlation between these two datasets/physical parameters were found, for example for limestone-dolostone (Figure 2). It will be necessary to verify these correlations with more data over other domains, and taking into account the variation of thermal conductivity in rocks, an issue that is being studied in detail by Di Sipio et al. (2013) in the frame of VIGOR project. However, for units that can be mapped with resistivity and show strong contrast of thermal conductivity, resistivity will help to constrain the thermal conductivity distribution at depth, therefore contributing to a detailed mapping of heat exchange at depth, to be used for low enthalpy geothermal system planning.

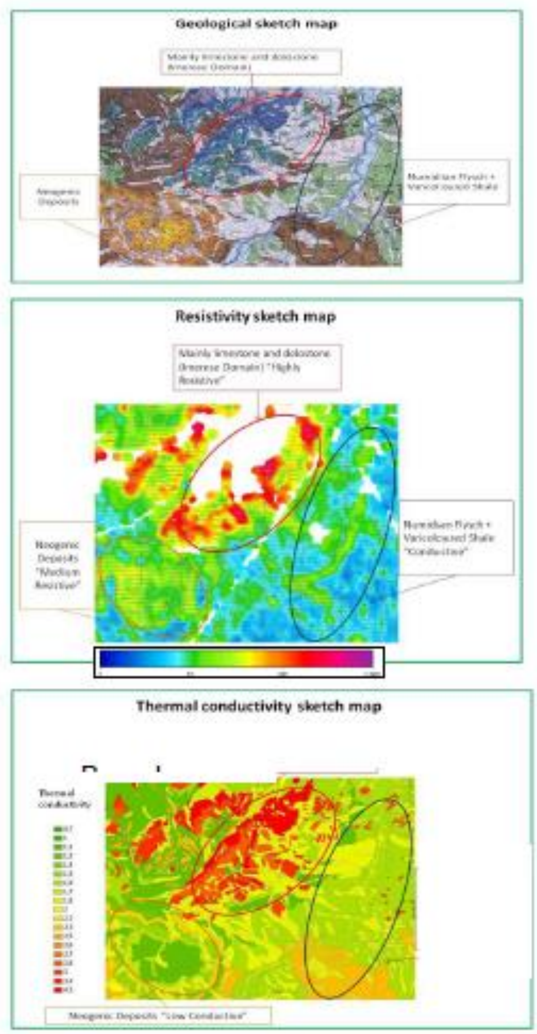

Figure 2