Electrical resistivity 3D modelling of the crust structure at Travale high enthalpy geothermal field

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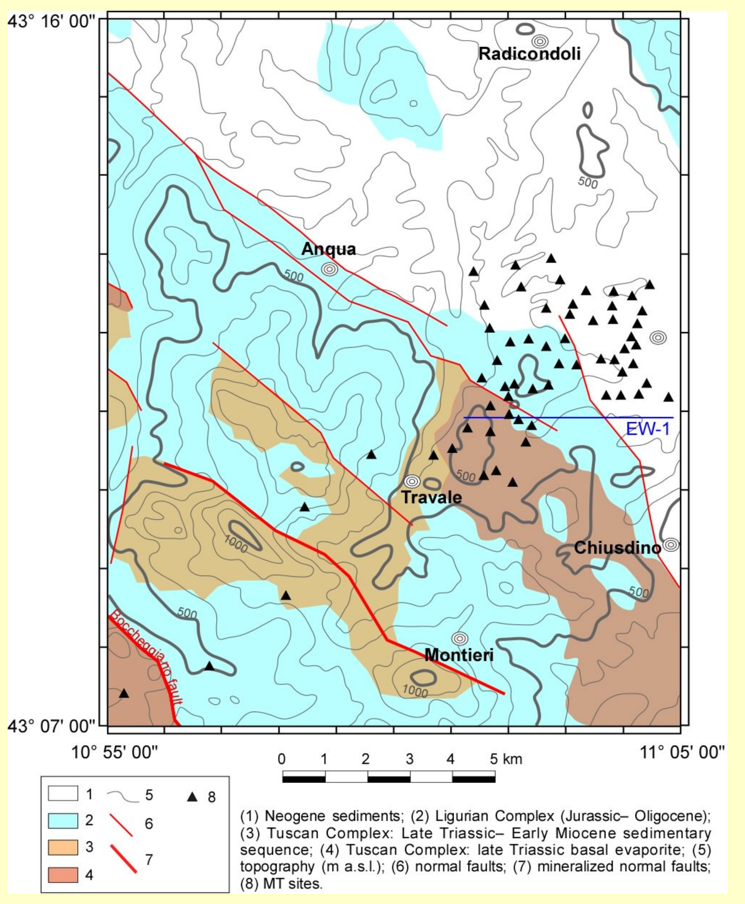
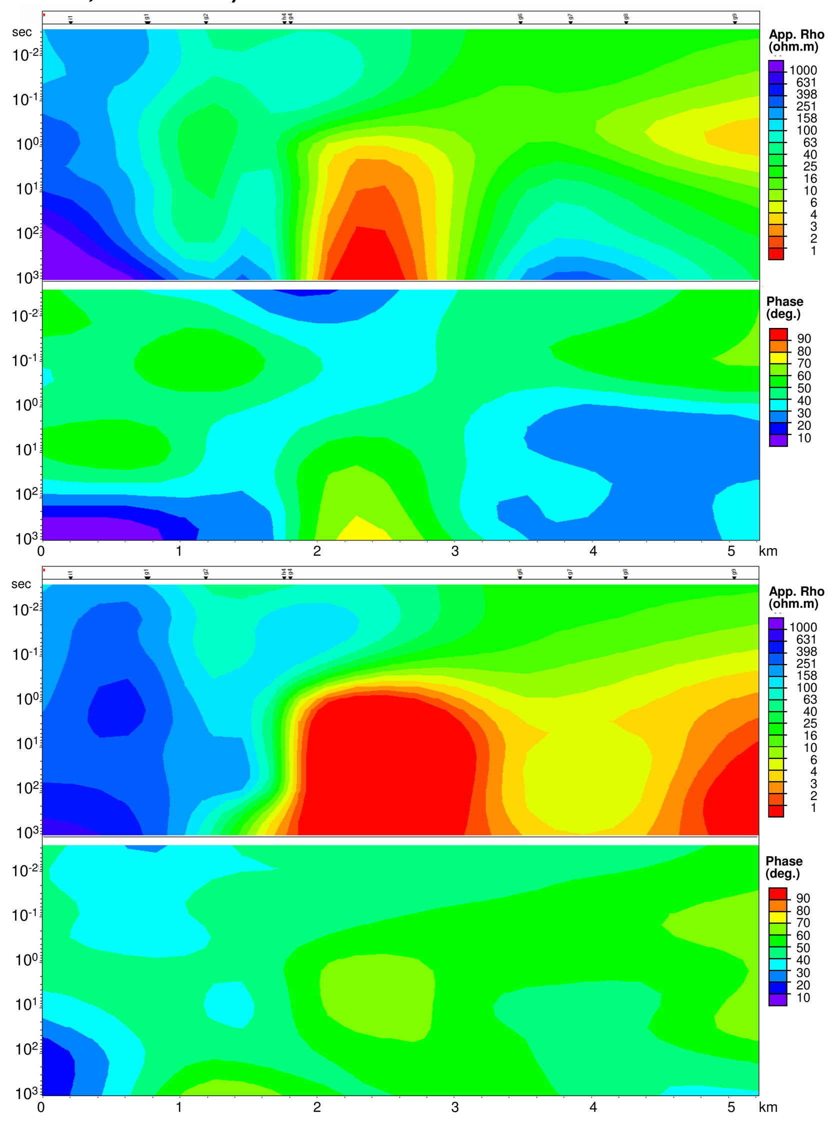
Geological map of Travale area



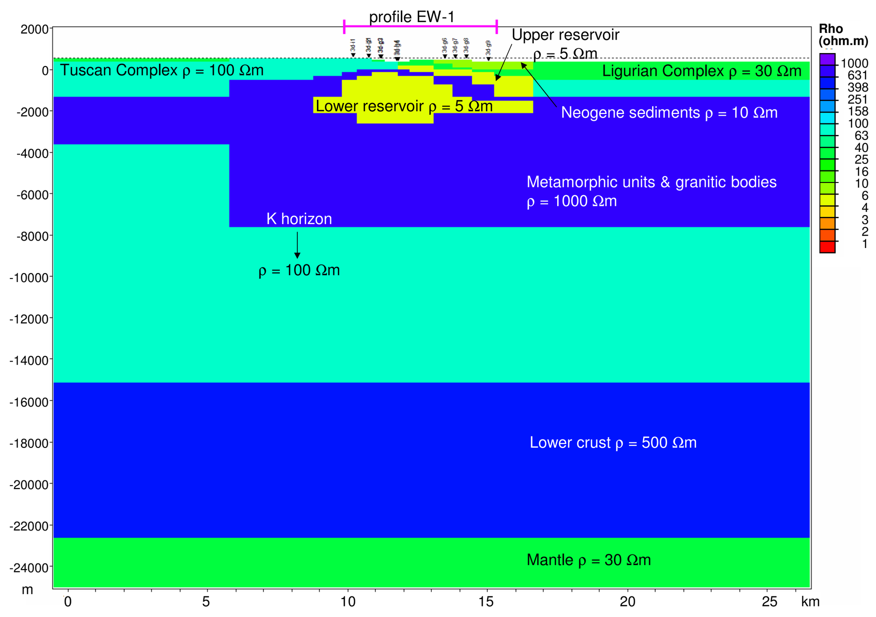
Pseudosections of measured MT data (profile EW-1; top TE, bottom TM)



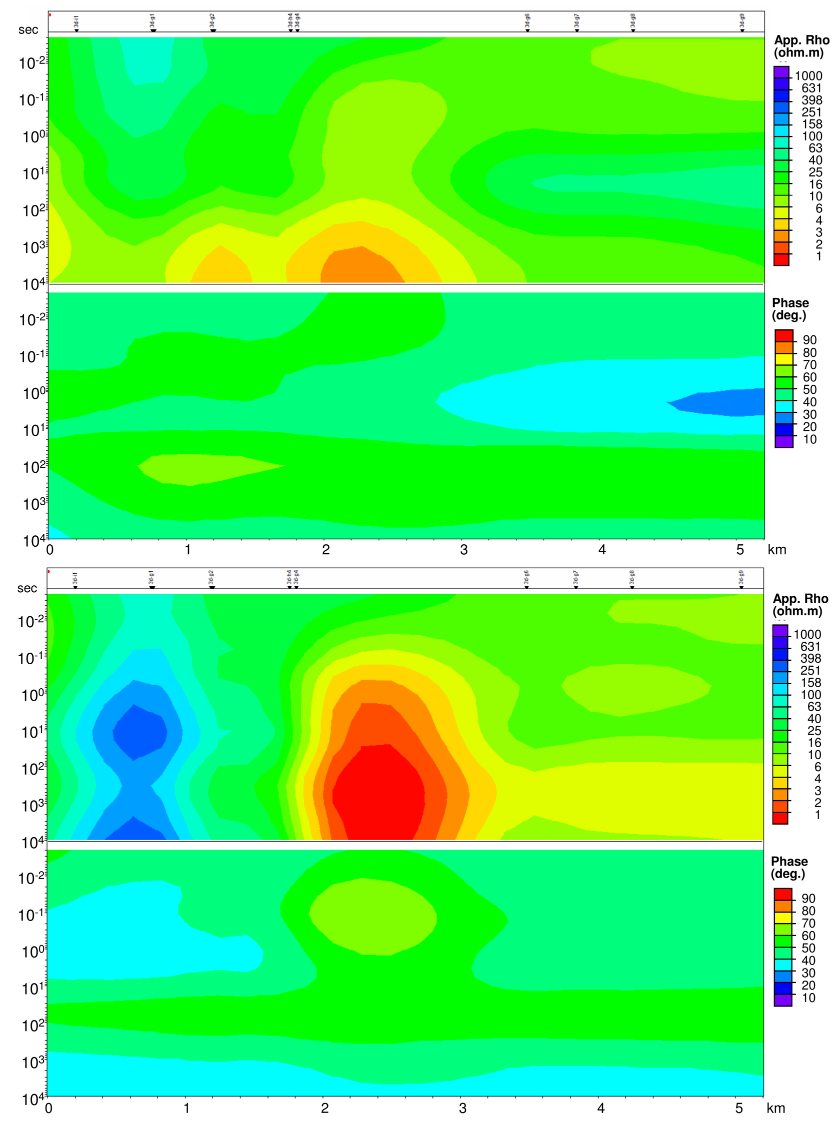
3D resistivity models of the Travale geothermal field and corresponding pseudosections from compute forward calculations

Different 3D models of Travale area were developed on the basis of 1) the resistivity of lithological units obtained from a resistivity log; 2) zones of high temperature and productive fractures indicated by drillholes; 3) bright-spot type horizons identified in seismic profiles; and 4) estimated resistivity values for the lower crust and mantle. Responses of forward modelling were calculated and compared with MT data measured in the field.

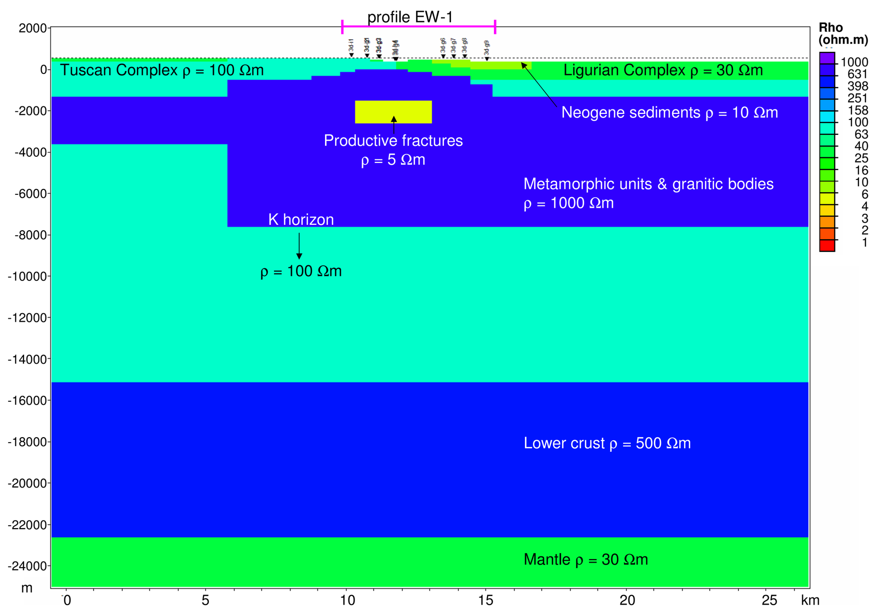
Model including upper and lower reservoirs, K horizon and conductive bottom



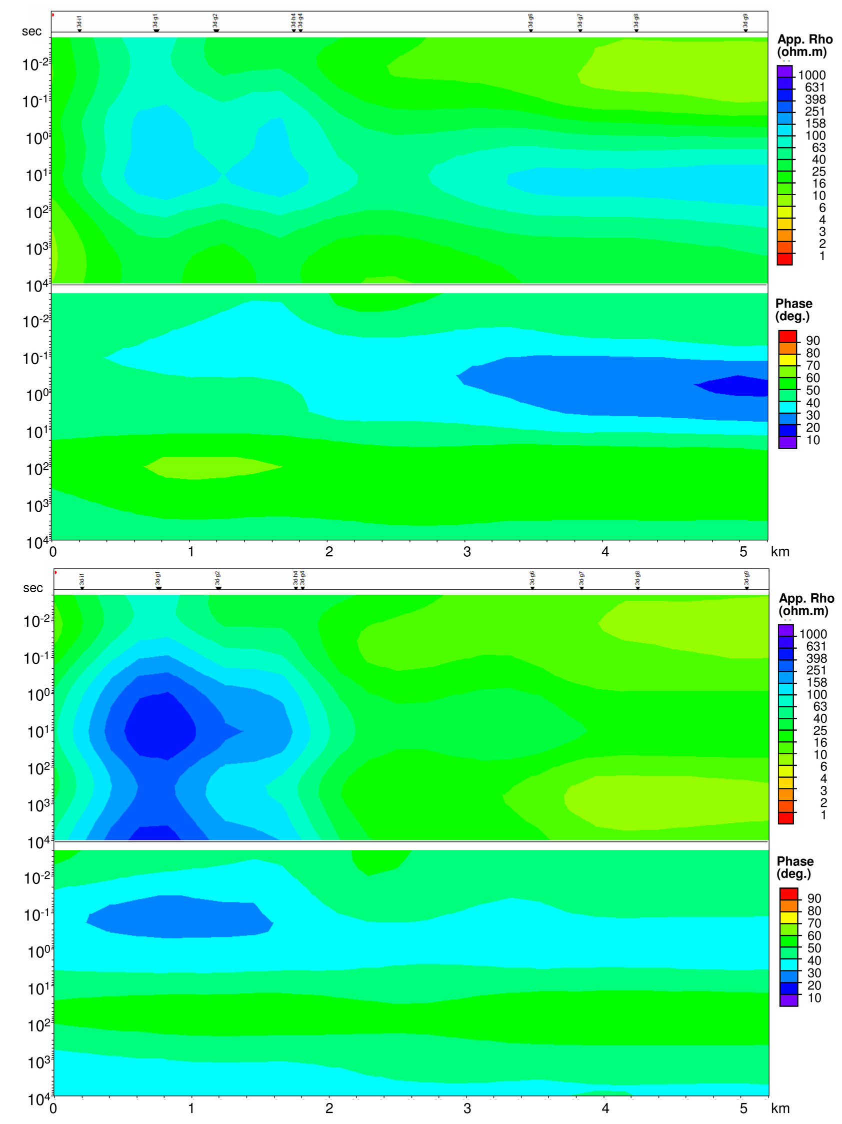
Pseudosections (profile EW-1; top TE, bottom TM)



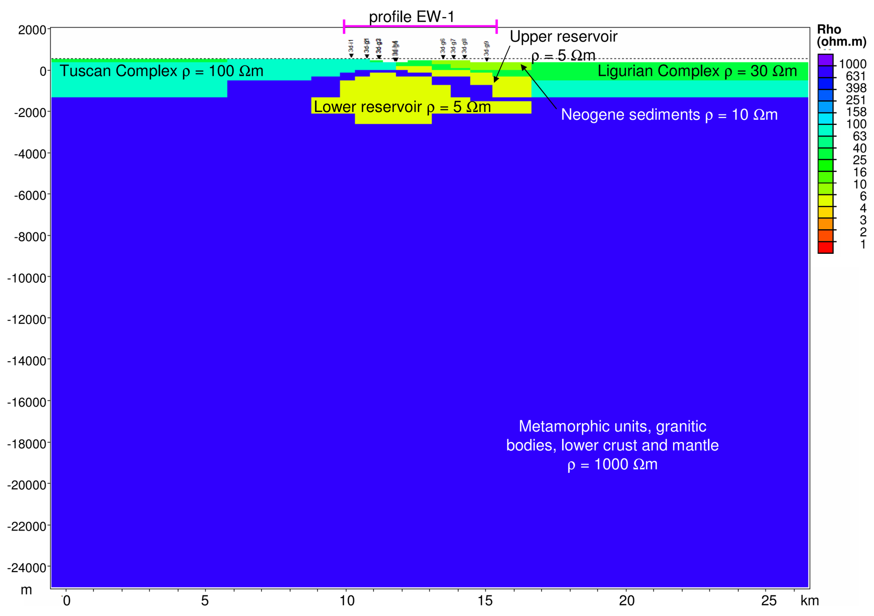
Model including reduced upper reservoir, productive fractures, K horizon and conductive bottom



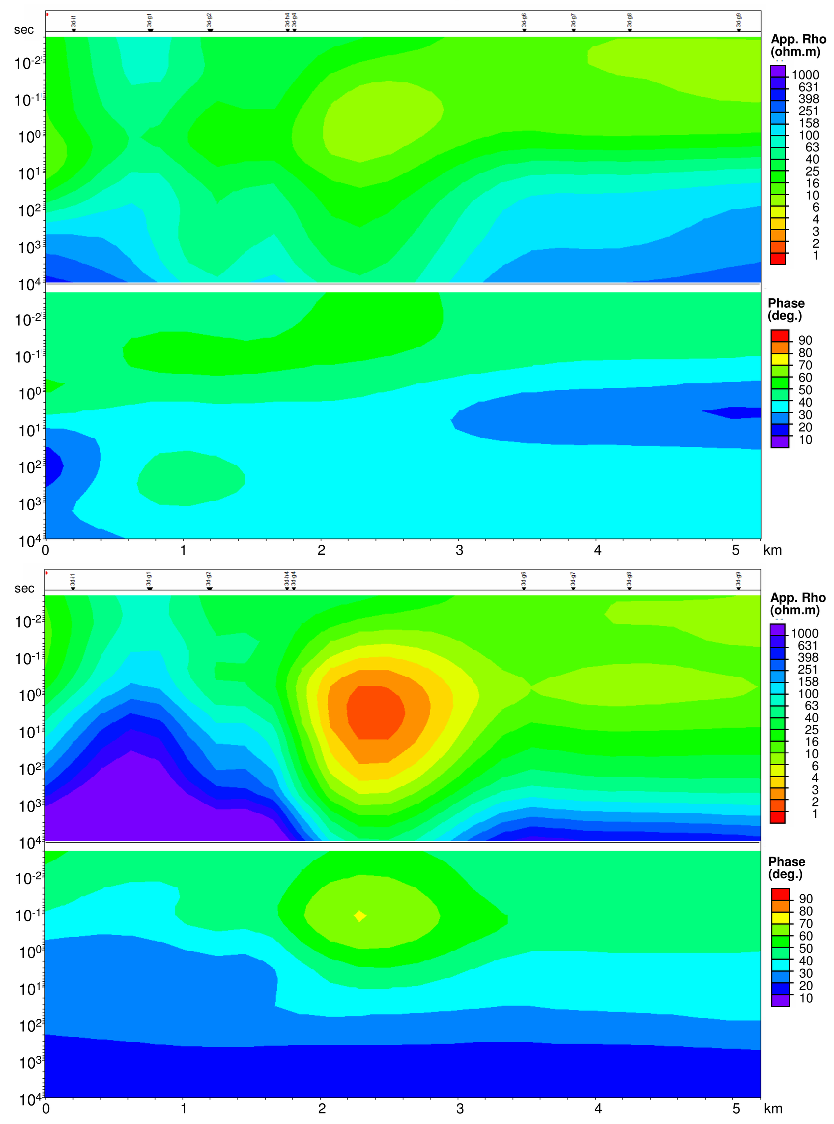
Pseudosections (profile EW-1; top TE, bottom TM)



Model including upper and lower reservoirs and resistive bottom

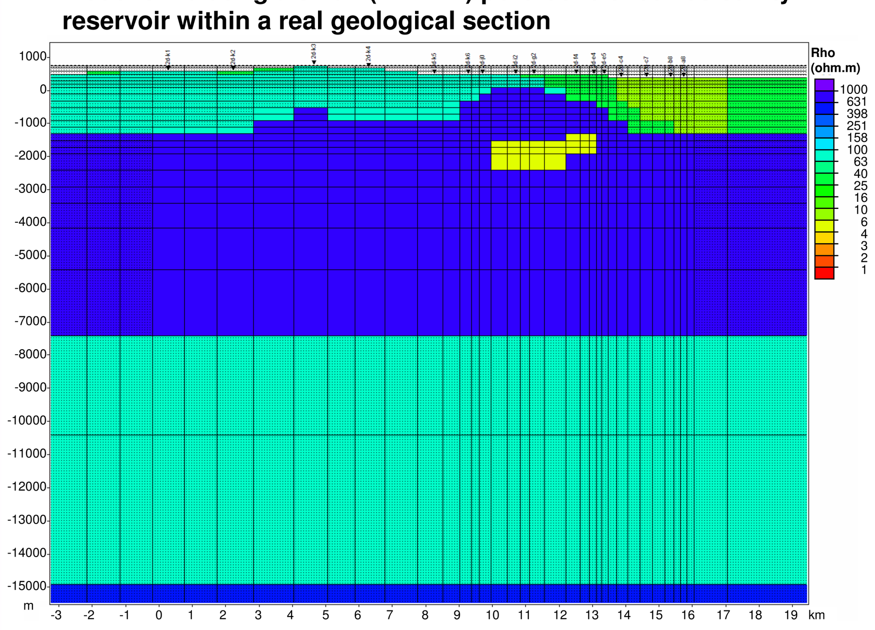


Pseudosections (profile EW-1; top TE, bottom TM)

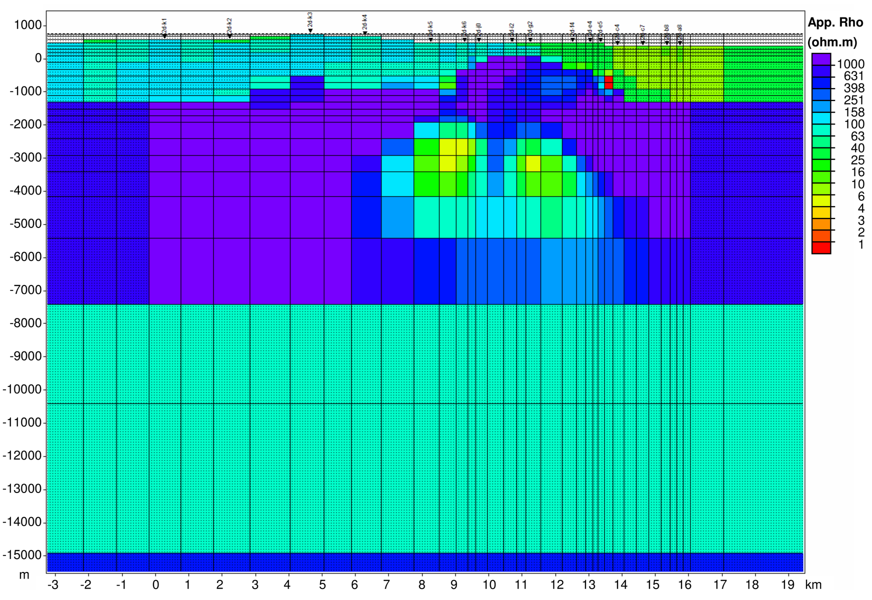


2D inversion test of models with different reservoir types

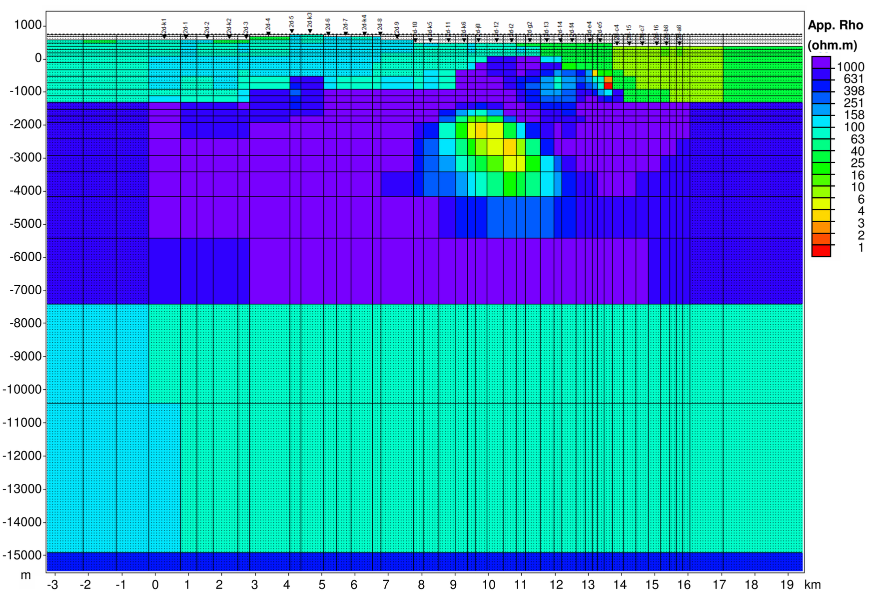
Model simulating a small (2.4 km^2) pore-controlled-resistivity reservoir within a real geological section



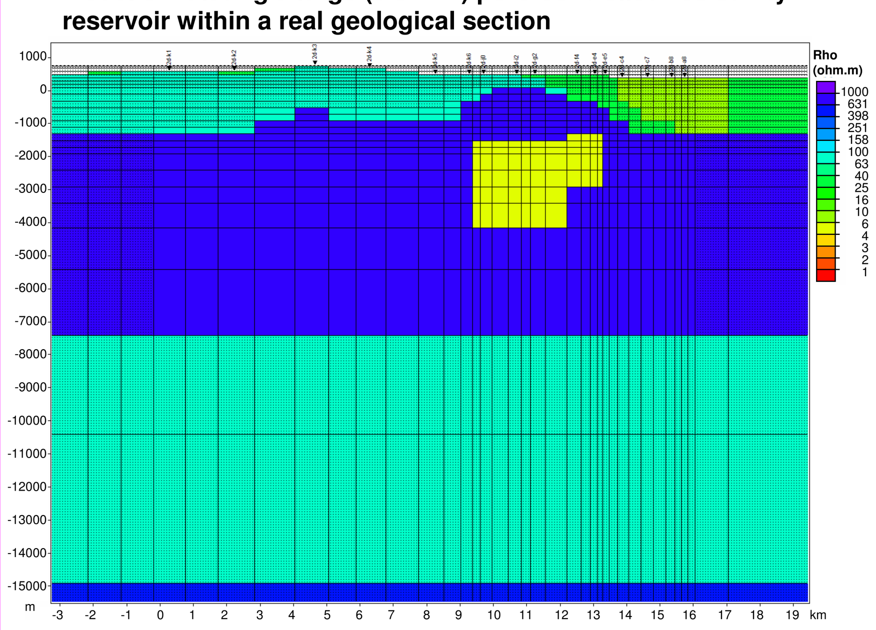
2D inversion (spaced MT stations)



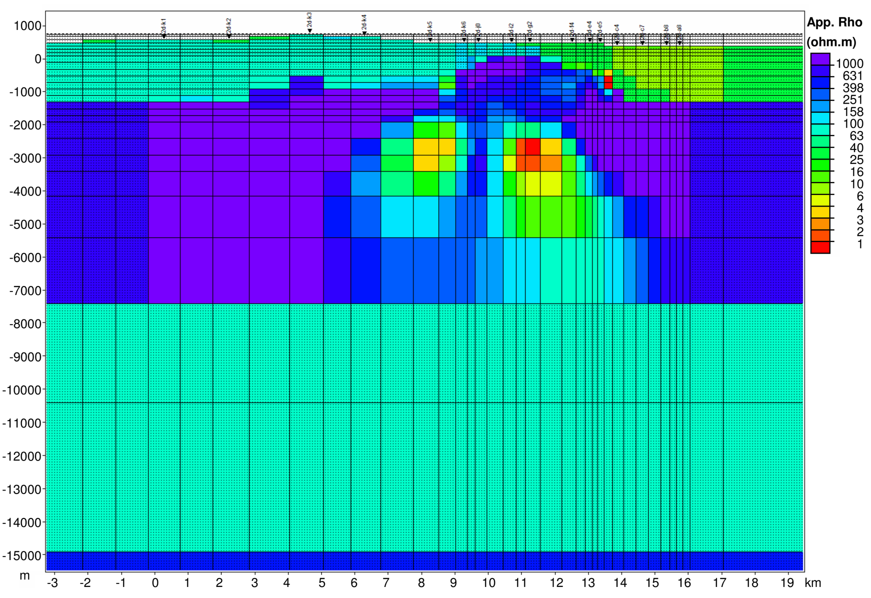
2D inversion (dense MT stations)



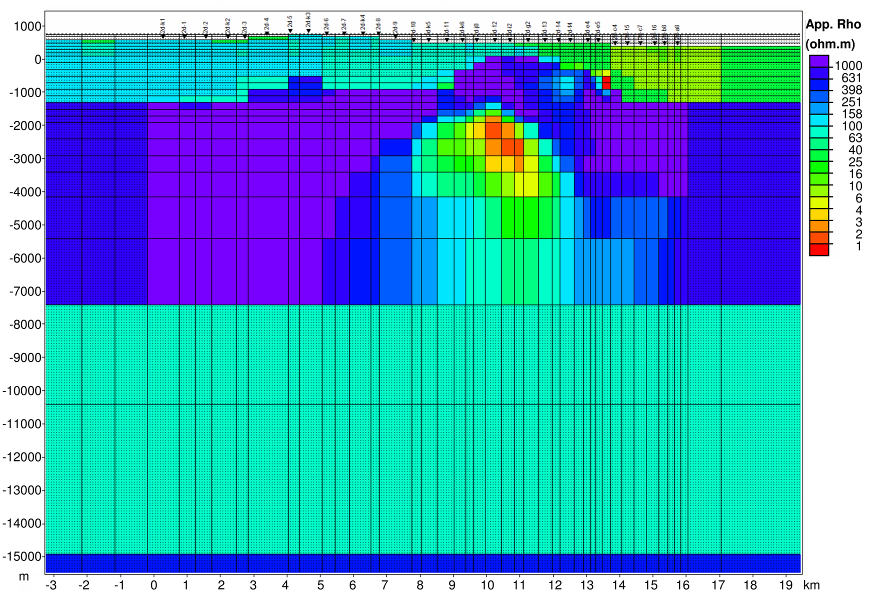
Model simulating a large (9.3 km^2) pore-controlled-resistivity reservoir within a real geological section



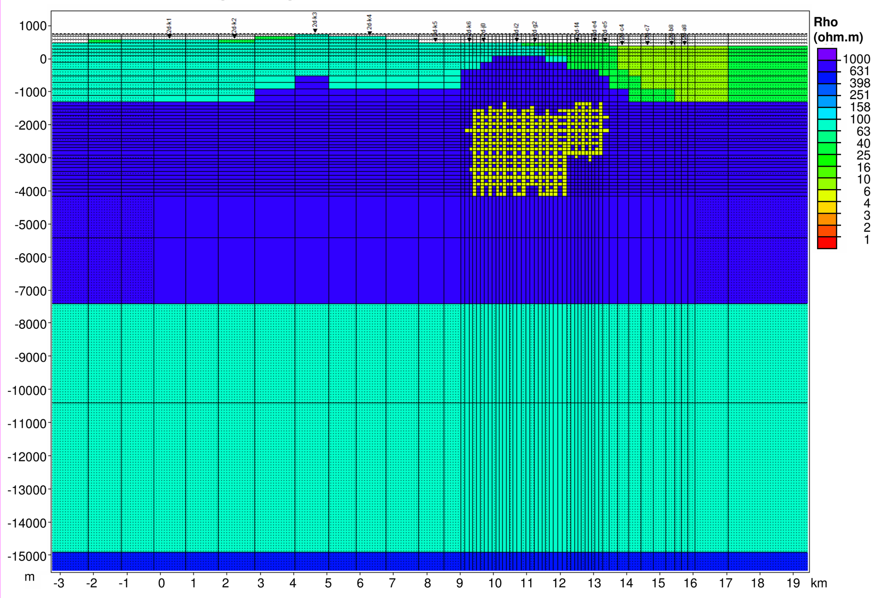
2D inversion (spaced MT stations)



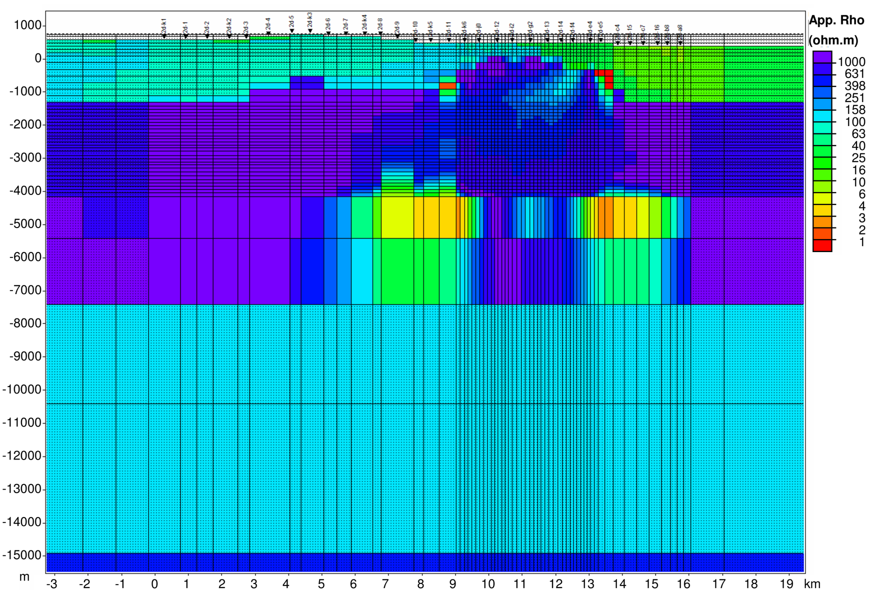
2D inversion (dense MT stations)



Model simulating fracture-controlled-resistivity reservoir within a real geological section



2D inversion (dense MT stations)



In order to determine whether magnetotellurics is capable to define different reservoir geometries and dimensions, and the minimum spacing of MT stations to attain enough resolution, a 2D inversion test was carried out on a resistivity profile from Travale area. We obtained compute forward calculations in models with different kind of reservoirs (pore-controlled-resistivity and fracture-controlled-resistivity) of various dimensions and used these results in 2D inversions of *a priori* models, *i.e.*, including only the electrical resistivities due to the lithological units.

Conclusions

3D resistivity modelling

- Neither the resistivity of the lithological units nor the presence of an upper and a lower reservoir limited to the currently productive fractures can explain the conductive anomaly evidenced by MT data at the Travale geothermal field.
- The closer fit to the measured MT data corresponds to the model comprising a deep conductive body of ~ 60 km^3 volume, *i.e.*, larger than the one enclosed by the currently exploited productive fractures.
- It is still a matter of discussion whether the conductive anomaly corresponds to a liquid phase within the lower reservoir, the presence of widespread, connected alteration minerals or both.
- When a relatively conductive lower crust and a conductive mantle are both present in the models, we obtain better fits to the measured MT data. This is in agreement with the resistivity decrease expected at these depths due to the higher temperatures and presence of melt phases in an active tectonic region such as southern Tuscany.

2D inversion of reservoir models

- In the models including the small and large pore-controlled-resistivity reservoirs, 2D inversions are able to define the lateral extent and top of the conductive bodies, but do not identify the bottom boundary. On a dense MT station profile (stations every ~ 500 m) the geometry of the reservoirs is attained with a slightly better resolution.
- The difference in size between the reservoirs is practically unattainable by 2D inversions. The MT method can only calculate the conductance (conductivity*thickness) of an anomalous body.
- In the case of the fracture-controlled-resistivity reservoir, 2D inversions are unable to define the grid of fractures, not even with a high density of MT stations. Furthermore, we obtain an overestimate of the anomaly depth.

Acknowledgements

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