Deep Electrical Resistivity Tomography as a mineral exploration tool: the Calamita distal Fe-skarn, Elba Island (Italy)

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ABSTRACT

MOTIVATIONS

The green transition has increased the demand for raw materials, making the search for new mineral deposits critical. Recent geophysical advances, such as Deep Electrical Resistivity Tomography (DERT) have allowed for the exploration of deeper ore bodies and larger areas while reducing logistical challenges. In this study, we use the innovative Fullwaver technology to decipher the geological structure of the Calamita distal Fe-skarn deposit, Italy and validate the potential of DERT as a mineral exploration tool.

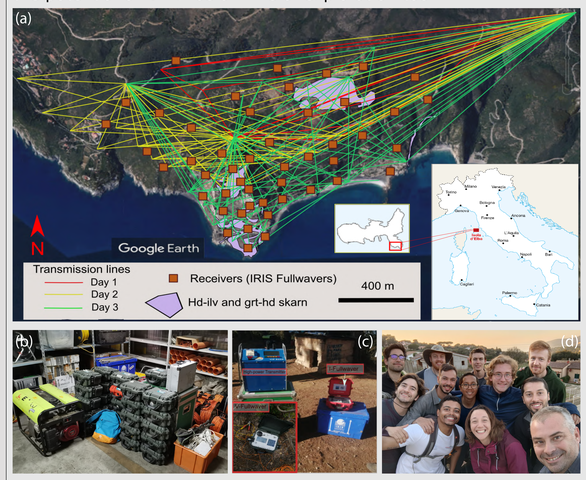


Fig. 1: (a) Field setup of the DERT acquisition with 150 transmission lines and 48 receivers. Skarn bodies are divided in 2 types with different mineralogy (i.e., hd: hedenbergite. ilv: ilvaite. grt: garnet). (b) Hardware used for the DERT survey. (c) The I-FullWaver (red box) records the current [A] injected into the ground by the high-power transmitter (blue box), while the V-FullWavers (green boxes) are deployed on the field and connected to two dipoles to record the potential difference [dV]. (d) 12 people needed for the field acquisition.

METHODOLOGY

A DERT survey has been carried out to image the subsurface geology of the deposit using the FullWaver technology (Fig. 3). This method allows a 3D and wireless disposition of autonomous receivers. We deployed 48 receivers over an area of 2 km² and performed 136 current transmissions (Fig. 1).

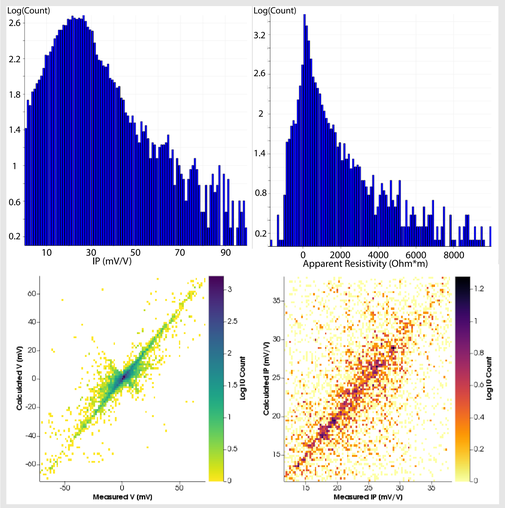


Fig. 3: Data overview. (a) apparent resistivity and (b) chargeability measurements. (c) Cross-plot for the resistivity data and for (d) the chargeability data

INVERTED MODELS

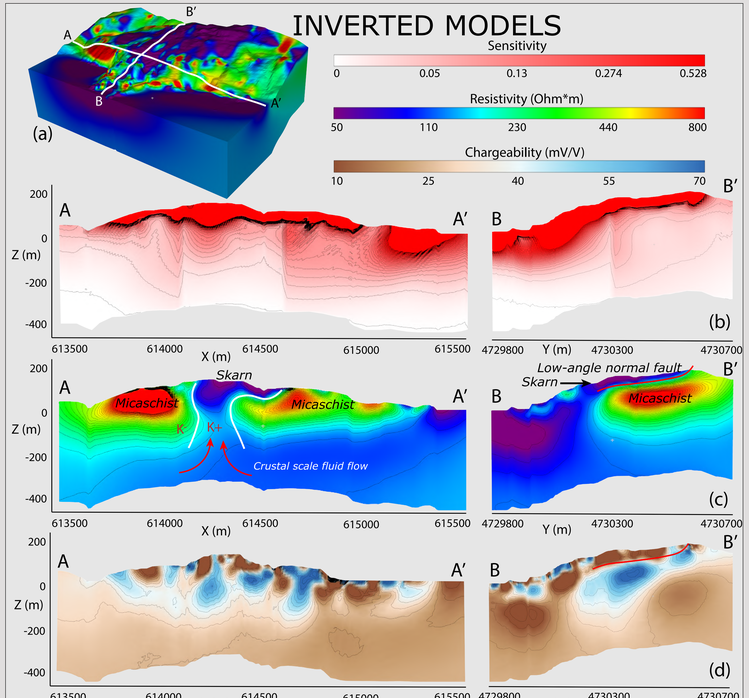


Fig. 4: (a) 3D resistivity model of the Calamita deposit. (b) Sensitivity sections. (c) Resistivity sections and interpretative model of observed strucures. K- and K+ represent a gradient in permeability. The conductive pipe is interpreted as the paleo fluid-flow channel. (d) Chargeability sections.

3D RESISTIVITY AND CHARGEABILITY MODELS

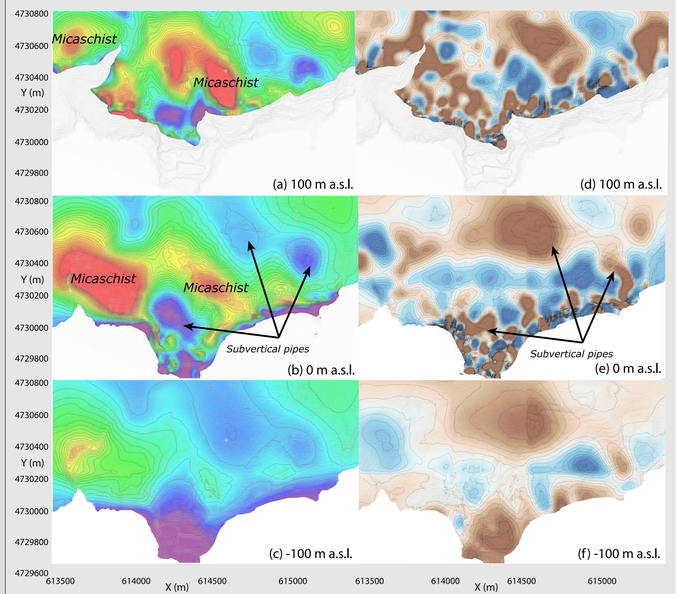


Fig. 5 : Horizontal slices of the inverted 3D resistivity and chargeability models.

GEOLOGICAL CONTEXT

The Calamita deposit consists of conductive massive magnetite-hematite ore bodies hosted in skarnified marbles, overlying highly resistive micaschists of the Tuscan Units. Exploration drillcores of the 1970's reached a maximal depth of 150 meters.

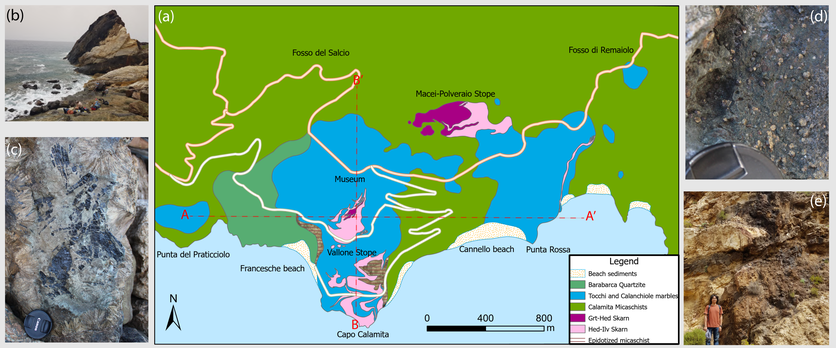
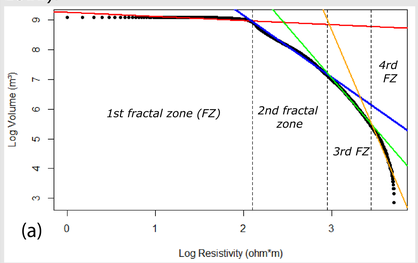


Fig. 2: (a) Geological map of the Calamita mine (after Dini et al (unpublished) et Bortolotti et al. (2016)). (b) Skarn lenses in marble. (c) Hedenbergite-ilvaite skarn. (d) Disseminated pyrite in micaschists. (e) Iron oxide ore

CV-FRACTAL ANALYSIS

The CV-fractal method allow to separate the inverted data into different populations on a log-log plot. The breakpoints on the curve are interpreted as delineating the different areas of the model based on their resistive properties (Afzal et al., 2011).



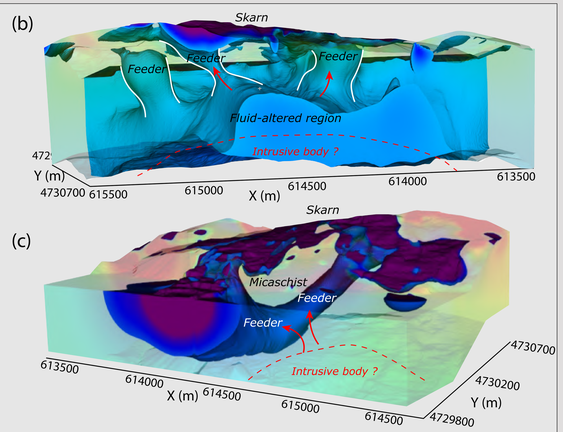


Fig. 6 : (a) The C-V log-log plot of electrical resistivity. The threshold values from the C-V multifractal model gives 4 populations. The most conductive population ranges from 0 to 130 Ohm*m and corresponds to the skarnified marbles and what has been intepreted as the «feeders» of the deposit. (b) 3D visualisation of first fractal zone of the resistivity model. The view is from the north. The conductive pipes are interpreted to point towards the cupola of a magmatic intrusion. (c) 3D visualisation of the inverted model with a focus on the conductive pipes. The view is from the south.

CONCLUSIONS

- The 3D resistivity and chargeability models match well with the surface geology and decipher the subsurface of the Calamita distal-skarn deposit. Conductive pipes are interpreted as paleo-hydrothermal upflow zones. A fault system appears to be the main vector for the skarn and ore-forming fluids.
- Additionally, high chargeable anomalies provide evidence for the presence of hidden disseminated mineralization at depth.
- The model brings new insights into the complex genesis of hydrothermal Fe-ores on Elba Island.
- This study demonstrates the potential of DERT for fundamental research and exploration purposes and highlights that new technologies may be a game changer for the exploration of ore deposits.

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