3D Deep Electrical Resistivity Tomography Study of the Calamita Distal Fe-Skarn Deposit, Elba Island (Italy): New Perspectives for Mineral Exploration

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The green transition has increased the demand for raw materials, making the search for new mineral deposits critical. Recent technological advances such as geoelectrical tools have allowed for the exploration of deeper orebodies and larger areas while reducing logistical challenges. In this study, we show the potential of deep electrical resistivity tomography (DERT) for mineral resource exploration. We use the Fullwaver technology to decipher the geological structure of the Calamita distal Fe-skarn deposit, Italy. Unlike conventional methods consisting in centralized acquisitions, this innovative, quasi-wireless system enables a flexible distribution of receivers, resulting in comprehensive 3D imaging of subsurface structures and orebodies' distribution at greater depth.

A 3D DERT survey was conducted in November 2022 to explore the Calamita deposit, involving 148 current injections on 48 receivers over an area of 2 km² to achieve exploration up to 700 m. Geophysical data were combined with shallow (200-m) exploration drill hole data.

The high-sensitivity 3D inverted resistivity and induced polarization models match well with the surface geology. The deposit consists of conductive massive magnetite-hematite orebodies hosted in skarnified marbles, overlying highly resistive micaschists of the Tuscan Units. Strong resistivity contrasts indicate the presence of sub-vertical conductive and chargeable pipes, connecting the various skarn bodies at depth. The pipes are interpreted as paleo-hydrothermal upflow zones, pointing towards the cupola of a potential causative magmatic intrusion. Additionally, high chargeable anomalies provide evidence for the presence of hidden massive orebodies and disseminated mineralization at depth. The model highlights the paleo-fluid circulation channels in this skarn deposit, bringing new insights into the complex genesis of hydrothermal Fe ores on Elba Island.

This study demonstrates the potential of DERT for fundamental research and mineral exploration purposes and highlights that new technologies may be a game changer for the exploration of ore deposits.