3D imaging of critical raw material resources using magnetotellurics

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SUMMARY

To meet the objectives of the European Green Deal, Europe requires an increase in the supply of raw materials. To extract these materials responsibly and sustainably the complex social, environmental and technical challenges and how they interact need to be understood. The EU funded project VECTOR aims to assess these challenges and integrate them to produce human centred solutions. In this framework, minimally disruptive geological and geophysical studies have been carried out at three different locations across Europe.

Here, we present the results of a magnetotelluric study conducted at Stonepark, a prospective region for Zn mineralization hosted by Carboniferous carbonates in the Irish Midlands. In late 2022, an MT survey was conducted using a novel experimental layout in which 33 five-component broad-band MT stations were deployed in concert with 75 two-component stations recording only the electric fields. The data exhibit strong EM noise but reasonable MT transfer functions could be obtained with the EMERALD processing suite in a frequency range of 10^{4}-10^{-2} Hz by using the robust remote reference technique in combination with notch filters (for 50 Hz signal and harmonics), and a novel criterion which is based on physical and statistical pre-selection thresholds.

The electrical conductivity structure at Stonepark revealed by 2D and 3D inversion shows excellent agreement with resistivity measurements on rock samples from nearby drillholes. This is remarkable since laboratory measurements work on cm-sized samples whereas MT soundings sample resistivities on volumes of 10s to 100s of meters. The mineral-bearing unit is imaged as highly resistive material typical for limestones with only small lateral variations of resistivity across the survey area (500 to 5000 Ωm). The MT models do not provide a direct image of economically mineralized zones. Yet, 2D models contain several additional low resistivity (< 100 Ωm) features with sizes < 1 km in the upper 1500 m of the subsurface. Plausible explanations such as presence of pyrite, as found in a drillhole located close to this feature, or correlation with a potential fault trace could already be inferred. Pyrite is commonly found near the mineralization bodies and could be a vector towards them.

Currently, we integrate the MT results with other geo-data including drillhole data, a detailed 3D geological model of the Stonepark mineral system, and re-processed seismic profiles. We discuss robustness of resistivity features, resolution capabilities, and possible implications based on complementary 3D conceptual models. In particular, we will address a possible continuation of the mineralized horizon to the south where it is not documented by drillholes and the potential of MT to map secondary features of the mineral system.

Keywords: critical minerals, exploration, magnetotellurics