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Induced polarization and transient electromagnetic surveys for the characterization of a graphite ore

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Introduction

Taking into account the anomalously low electrical conductivity of electrical semi-conductorselectrical geophysical DC-resistivity methods are commonly used in the prospection of sulphide ores.

Accordingly, DC-resistivity methods have been proposed for the exploration of graphite, an electrical conductor. However, the interpretation of the electrical resistivity can be challenging in those cases were both iron-sulfides and graphite are present, such as the case of the Zettlitz site (see Figure 1).

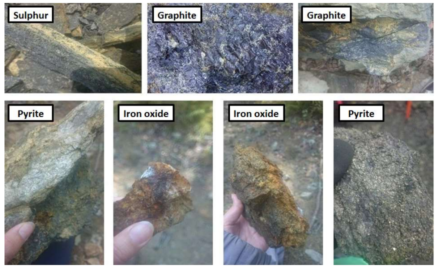

Figure 1: Pictures of the main materials observed at the study area: graphite schists (an electrical conductors), iron-oxides (poor electrical conductors) and iron-sulphides (electrical semi-conductors)

To improve the interpretation of the electrical results, we investigate here the application of the Induced Polarization (IP) imaging method. This is an extension of the DC-resistivity method, that provides information of electrical resistivity and capacitive properties.

We present IP results for data collected in Zettlitz (Austria) a former graphite quarry, which was operated between 1855 and 1967, were abundant iron- oxides and sulfides are present (Figure 1).

Laboratory results

Initial measurements conducted in synthetic samples with pyrite and graphite samples with a similar grain size distribution. Results are presented in Figure 2 in terms of the magnitude (ρ) and phase (ϕ) of the complex resistivity. Whereas the resistivity reveals a similar response for both minerals, the polarization exhibits a clear difference, especially for measurements collected at different frequencies

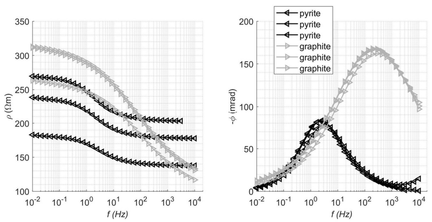

Figure 2: IP results for measurements collected in the laboratory expressed in terms of the magnitude (ρ) and phase (ϕ) of the complex resistivity, which represent the electrical resistivity and polarization properties.

Study area

Here we discuss results for IP data collected in the Zettlitz (Austria), a former quarry operated between 1855 and 1967 for the extraction of graphite. A geological map for the study area is presented in Figure 3, along with the position of the main profiles discussed here.

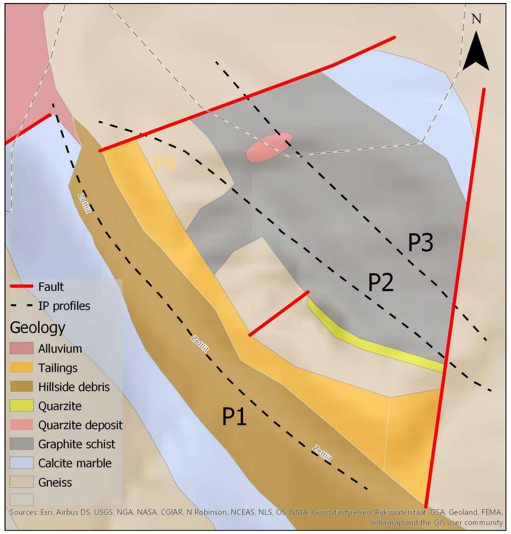

Figure 3: Geological map of the Zettlitz study area. The position of the IP profiles indicated by the dashed lines.

Initial characterization

Figure 4 shows the IP imaging results for data collected along P1 at 1Hz. Such measurements aimed at providing a general investigation. The results reveal an undistinctive response in terms of the electrical resistivity (ρ), hindering an adequate delineation of the graphite-rich unit. Opposite to that, images of the IP response (ϕ) clearly reveal a clear anomaly with a thickness of ca. 45m associated with anomalously high values, corresponding to the graphite rich debris unit.

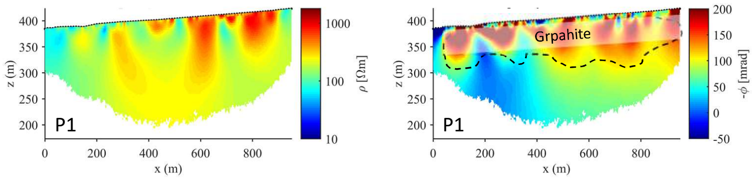

Figure 4: IP imaging results for measurements collected at 1 Hz along P1, the graphite-rich unit is indicated by the dashed line

Detailed investigation

Imaging results presented in Figure 5 present the results obtained for measurements conducted in P2 and P3. While the resistivity images (ρ) reveal mainly an anomaly characterized by low values, the IP images (expressed in terms of ϕ) reveal sharp anomalies which indicate the graphite-rich areas, permitting to delineate a maximum thickness of approximately 15 m which can not be resolved in the resistivity images.

The lower ϕ values observed in P2 and P3, when compared with P1, suggest a lower volumetric content of graphite in these profiles.

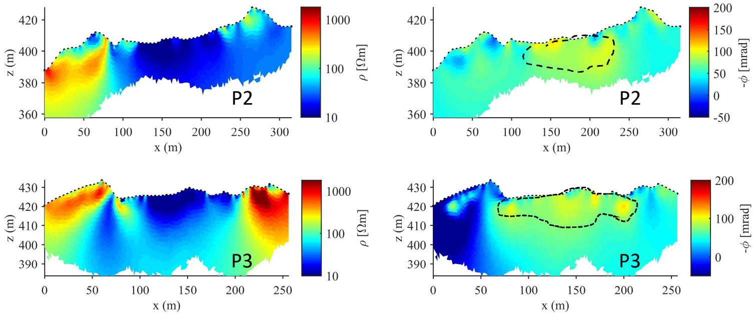

Figure 5: IP imaging results for measurements collected at 1 Hz along P2 and P3. The graphite-rich unit is indicated with the dashed line

Outlook and Conclusions

Our results demonstrate the applicability of the IP imaging method for the characterization of graphite-ores. In particular, we observed an anomalously high polarization response ($|\phi|$ > 100 mrads) corresponding to areas rich in graphite. The resistivity response observed in such areas is undistinctive, with relative high values observed in debris material (as expected due to the poor consolidation), and significantly low values in the graphite schists.

Our results suggests that electrical resistivity in field imaging results is controlled not only by the presence of electronic conductors, but by the weathering and compaction of the materials. On the opposite, the IP response appears t be mainly related to the volumetric content of the electronic conductor, i.e., the graphite content.

IP measurements collected at higher frequencies revealed significant distortions due to parasitic electromagnetic field, commonly referred to as electromagnetic (EM) coupling. Such coupling increases with increasing the electrical conductivity, the frequency and the length of the cable used on the field. Due to the electrical properties of graphite, field IP measurements will be limited at high frequencies due to EM coupling; thus. To overcome such problem, an alternative correspond to the use of Transient Electromagnetic (TEM) soundings.

To discuss the results obtained by means of TEM soundings, and further measurements with the IP method, do not hesitate to cotact us at: flores@tuwien.ac.at

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