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Spectral induced polarization imaging of a graphite deposit

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The prospection of graphite deposits is receiving more interest in current geophysical research. This is mainly due to the possibility to use graphite for the fabrication of environmentally friendly batteries. Aiming at the development of an efficient prospection technique, we have investigated the capabilities of the spectral induced polarization (SIP) method for the prospection of graphite and the quantification of its textural parameters (e.g., matrix properties). Here, we present SIP imaging results from the grounds of a former graphite mine. The study area is located close to Zettlitz in Lower Austria, where a graphite mine was active between 1855 and 1966. The deposit is composed of graphite schist, interleaved with pyrite and iron oxides. Hence, the study area poses challenging conditions regarding the presence of two highly electrically conductive materials. We hypothesize that the frequency dependence of the subsurface electrical conductive and capacitive properties (as assessed by SIP) can be used to discriminate between graphite, iron sulfides, and iron oxides, as required for a quantitative characterization of the site. SIP measurements have been conducted in both frequency- and time-domain IP to investigate possible advantages and drawbacks of both techniques regarding signal strength and data quality. We have also conducted transient electromagnetic (TEM) soundings to independently solve for the electrical conductivity and aid in the evaluation of the SIP imaging results. Moreover, SIP laboratory measurements have been performed on synthetic samples using well-defined composition and content of graphite, pyrite, and iron oxides, as well as on samples retrieved from the field site. For the interpretation of the SIP signatures and the estimation of parameters of interest (e.g., graphite/iron content), we have also modelled the laboratory measurements using recently developed electrochemical models. Our results demonstrate the applicability of the SIP method to improve the resolution of the various geological units at the test site and, in particular, to delineate the geometry of the graphite unit. Moreover, both field and laboratory results reveal a significant frequency-dependence of the electrical properties of graphite, even at low frequencies (<1 Hz). However, our results also demonstrate the necessity of further investigations as the discrimination between iron-bearing minerals and graphite-rich materials remains challenging.