Non-linear Spectral Induced Polarization effects in Porous Media Containing Electron Conducting Minerals

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Abstract

Spectral Induced Polarization (SIP) is a geophysical technique widely employed to explore metallic and non-metallic mineralization by measuring the complex impedance across a range of frequencies. A non-linear SIP effect may occur in the presence of electron-conducting minerals when a current is injected. A pathway occurs in the presence of a charge transport processes involving redox reactions, referred to as the "faradaic pathway". The strength of this non-linear effect is expected to depend on the electrochemistry of the metal-electrolyte interface, as well as the texture of the electron conductors. This study investigated the strength of the faradaic process across a variety of electron-conducting minerals. Laboratory measurements were conducted on synthetic electron-conducting mineral-sand mixtures and rock samples exhibiting both veinlet and disseminated mineralization. The non-linear SIP effect was quantified by applying a range of current densities and determining the degree of linearity between SIP response and applied current density. Compared to disseminated mineralization, veinlet mineralization results in much stronger non-linear SIP effects. However, some electron-conducting minerals exhibited strong non-linear effects (e.g., copper minerals), whereas others showed negligible non-linear effects irrespective of texture (e.g., graphite). These differences are directly linked to mineralogy, raising the possibility that the faradaic effect can provide information for discriminating electron-conducting minerals and rock texture.