STANDOFF BROADBAND LOW-FREQUENCY EMI

D. R. Glaser, US Army ERDC Cold Regions Research & Engineering Laboratory, Hanover, NH USA
B. E. Barrowes, US Army ERDC Cold Regions Research & Engineering Laboratory, Hanover, NH USA
F. Shubitidze, Thayer School of Engineering, Dartmouth College, Hanover, NH USA
L. D. Slater, Rutgers University, Earth & Environmental Sciences Department, Newark, NJ USA

Standoff electromagnetic induction (EMI) sensing techniques offer efficient, in-situ characterization of the electrical properties of soils. Galvanic, or direct, electrical measurements of soils offer the ability to further correlate relaxation responses with soil physical properties through pedophysical modeling. Our efforts seek to leverage the benefits of both standoff EMI and direct electrical measurements. As such, we studied and compared electrical (spectral induced polarization (SIP)) and EMI phenomena over the frequency range of 3 Hz through 10kHz. A low-frequency EMI instrument was developed (LFEMI), modeled after our high-frequency EMI (HFEMI) system (nominally 1kHz - 20MHz), looking to overcome HFEMI's limitations when measuring physical parameters such as permittivity of low conductivity materials including soils. The HFEMI system was initially designed for the detection of improvised explosive devices and unexploded ordinance which have a high conductivity when compared to soils, resulting in a much higher signal-to-noise ratio making the response easier to observe. We investigated low frequency measurements of low conductivity samples, and where the HFEMI system was less effective at extracting relaxation curves of the inphase and quadrature components of the secondary magnetic field from soil or other media. In addition, HFEMI measurements often contained significant 1/frequency (1/f) instrument noise at low parts of the frequency band, also known as pink noise, that obscured the signal of interest from the soil. The LFEMI employs larger diameter coils with a greater number of turns to improve the signal-to-noise ratio (SNR) at low frequencies allowing measurements as low as 1 Hz. Further, the desired effect of reduced noise and removal of the 1/f noise was substantially achieved. EMI measurements in this broadband, low-frequency measurement range can be correlated with direct SIP complex electrical conductivity measurements of soils. We seek to observe relaxation type responses within the LFEMI signal indicative of mechanistic polarization type phenomena, i.e. ionic charge relaxation. We present LFEMI results for engineered soils consisting of sand-pyrite mixtures with comparisons to direct electrical measurements of the same.