Superimposed IP relaxations in sand and silty clay deposits measured in the time domain

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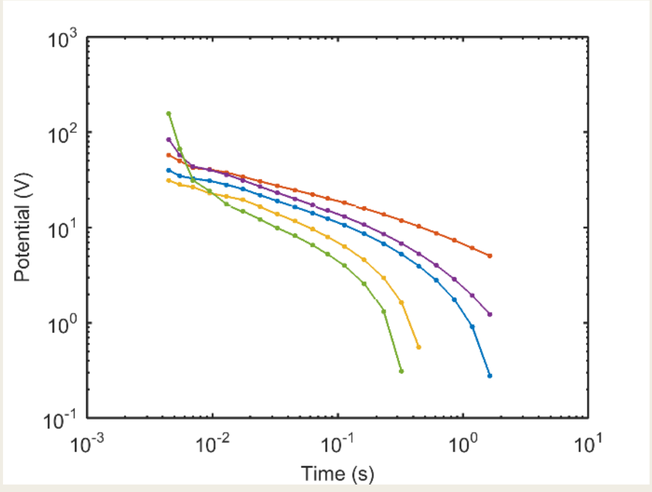
Can several IP relaxations be distinguished in time domain data?

Motivation

- Observation of measured decay curves which, at early decay times, deviate from the common exponential shape.
- Several phase peaks have been observed previously in laboratory SIP measurements, probably caused by multiple dominant length scales in the material.

Field measurements were made at sand pit, consisting of medium sandy fine sand (to 9 meters depth) above silty clay (to 32 meters depth).



Broad time range decays (0.07-2s, extracted with signal processing algorithm) indicate spectral variations.

Synthetic data - Superimposed high- and low frequency Debye relaxations. The superimposed decay shape (black line) depends on the relative relaxation strengths.

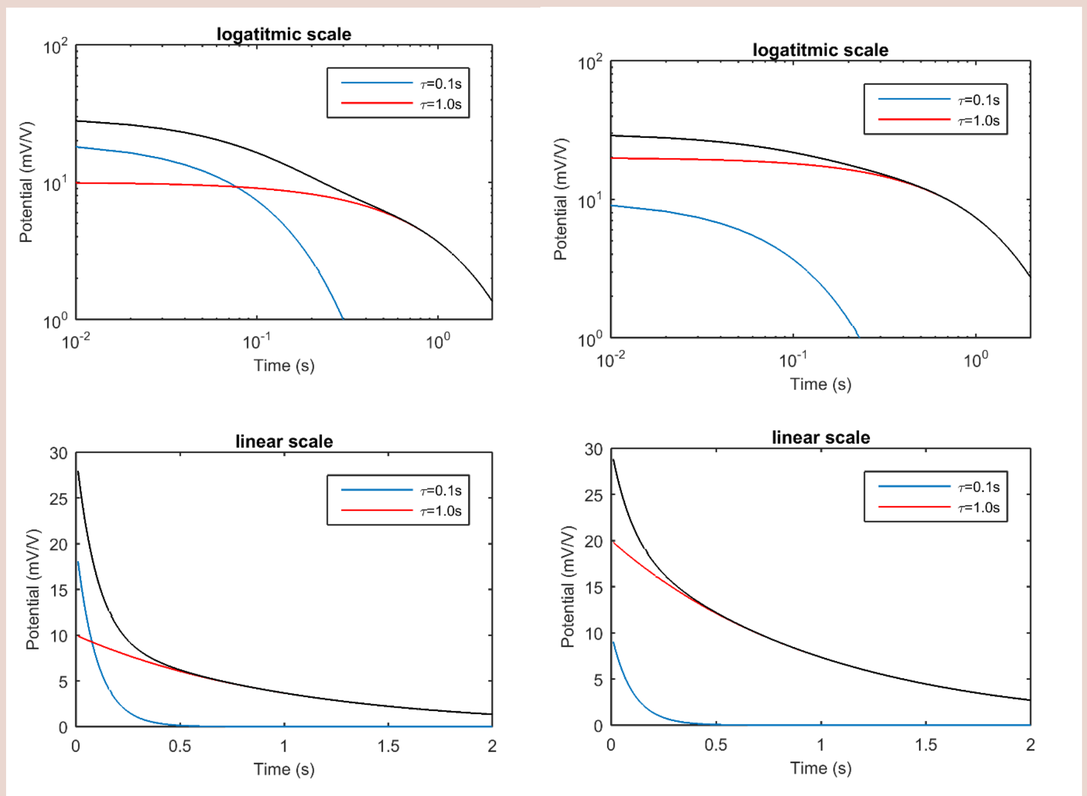
Field data – Raw decays fitted with either one low frequency Cole-Cole relaxation (solid line) or two superimposed Cole-Cole relaxations (dashed line). The low frequency relaxation was fitted before superimposition of the high frequency relaxation.

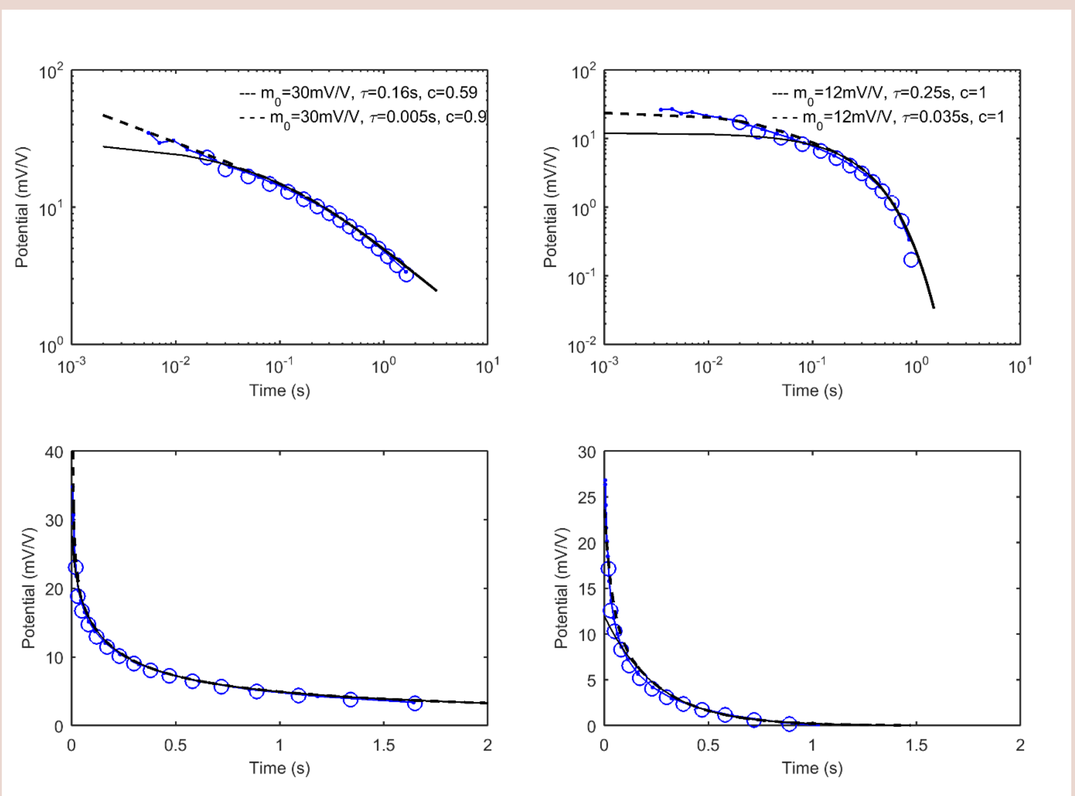
m_{0high} = 20mV/V
m_{0low}= 10mV/V

m_{0high} = 10mV/V
m_{0low}= 20mV/V

2m focus depth

11m focus depth





Results

- Chargeability values in sand (2m focus depth): 12mV/V. Relaxations at 4Hz and 29Hz indicate two dominant length scales (fine sand and medium sand).
- Chargeability in silty clay (11m focus depth): 30mV/V. Relaxations at 6Hz and 200Hz indicate interfacial or coupling effects at high frequencies.

Conclusions

- High frequency relaxations can have their origin in short polarizable length scales, interfacial polarization mechanisms, coupling effects or the distribution of Cole-Cole parameters in the subsurface.
- Superimposed relaxations can be detectable with time domain IP.

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