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On the convenience of static and dynamic transfer functions in seismoelectric data: the role of permeability

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Usually studied in the seismic range, co-seismic electric fields associated to electrokinetic phenomena are interpreted in light of the low frequency transfer functions proposed by Garambois and Dietrich (2001). Nevertheless, the convenience of this assumption in the sonic and ultrasonic range is poorly discussed, despite promising applications for the characterization of transport and fluid properties in borehole measurements. As shown by Pride and Haartsen (1996), the complete dynamic transfer function from grain acceleration $\ddot{u}(\omega)$ to electric field $E(\omega)$ for fast P waves is given by:

$$E(\omega)/\ddot{u}(\omega) = \frac{\tilde{\rho}(\omega)\ L(\omega)}{\tilde{\varepsilon}(\omega)}\beta_L(\omega)$$

where $\tilde{\rho}(\omega)$ is the flow resistance density term, $\tilde{\varepsilon}(\omega)$ the effective dielectrical permittivity, $\beta_L(\omega)$ the mechanical coupling and $L(\omega)$ is the dynamic electrokinetic coupling. In this study, we explore these theoretical dynamic transfer functions through a parametric study focussing on the role of intrinsic permeability. The results are compared to real data acquired in a laboratory experiment that consists in measuring seismic and seismoelectric data into a tank filled with moist sand. For this purpose, synthetic seismoelectric data are computed by applying the low frequency and dynamic transfer functions to the seismic records. These synthetic data are compared to measured seismoelectric recordings, in term of magnitude and waveform. This comparison shows that permeability may have strong influence on seismoelectric couplings as soon as measurements are performed in the kilohertz range. In addition, earlier events in seismoelectric signals measured in very permeable media, often presented as "precursors", can be induced by the non negligible imaginary part of the dynamic transfer function. In order to improve the understanding of these theoretical results, the role of permeability will be also investigated through specifically designed experiments. Eventually, this communication will open on further aspects of our lab works showing the role of acquisition geometry on magnitude and frequency content.