POLARIS: a model to understand and interpret spectral induced polarization data in Earth sciences

A. Revil[(1),(2)]

(1) *Colorado School of Mines, Golden, CO. USA*
(2) *CNRS, ISTERRE, Grenoble, France*

A model combining low frequency complex conductivity and high frequency permittivity is developed in the frequency range from 1 mHz to 1 GHz. The low frequency conductivity depends on pore water and surface conductivities. Surface conductivity is controlled by the electrical diffuse layer, the outer component of the electrical double layer coating the surface of the minerals. The frequency dependence of the effective quadrature conductivity shows three domains. Below a critical frequency f_p that depends on the dynamic pore throat size, the quadrature conductivity is frequency dependent. Between f_p and a second critical frequency f_d, the quadrature conductivity is generally well described by a plateau when clay minerals are present in the material. Clay-free porous materials with a narrow grain size distribution are described by a Cole-Cole model. The characteristic frequency f_d controls the transition between double layer polarization and the effect of the high frequency permittivity of the material. The Maxwell-Wagner polarization is found to be relatively negligible. For a broad range of frequencies below 1 MHz, the effective permittivity exhibits a strong dependence with the cation exchange capacity and the specific surface area. At high frequency, above the critical frequency f_d, the effective permittivity reaches a high-frequency asymptotic limit that is controlled by the two Archie's exponents m and n like the low-frequency electrical conductivity. The unified model is compared with various datasets from the literature and is able to explain fairly well a broad number of observations with a very small number of textural and electrochemical parameters. I will discuss also the effect of pore size on the distribution of the relaxation times and the relationship between the quadrature conductivity and the surface conductivity.